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PREFACE

EAPRIL is …

EAPRIL is the European Association for Practitioner Research on Improving Learning. The association promotes practice-based and practitioner research on learning issues in the context of formal, informal, non-formal, lifelong learning and professional development with the aim to professionally develop and train educators and, as a result, to enhance practice. Its focus entails learning of individuals (from kindergarten over students in higher education to workers at the workplace), teams, organisations and networks.
More specifically:

- Promotion and development of learning and instruction practice within Europe, by means of practice-based research.
- To promote the development and distribution of knowledge and methods for practice-based research and the distribution of research results on learning and instruction in specific contexts.
- To promote the exchange of information on learning and instruction practice, obtained by means of practice-based research, among the members of the association and among other associations, by means of an international network for exchange of knowledge and experience in relation to learning and instruction practice.
- To establish an international network and communication forum for practitioners working in the field of learning and instruction in education and corporate contexts and develop knowledge on this issue by means of practically-oriented research methods.
- To encourage collaboration and exchange of expertise between educational practitioners, trainers, policy makers and academic researchers with the intent to support and improve the practice of learning and instruction in education and professional contexts.
- By the aforementioned goals the professional development and training of practitioners, trainers, educational policy makers, developers, educational researchers and all involved in education and learning in its broad context are stimulated.

Practice Based and Practitioner Research

Practice-based and practitioner research focuses on research for, with and by professional practice, starting from a need expressed by practice. Academic and practitioner researchers play an equally important role in the process of sharing, constructing and creating knowledge to develop practice and theory. Actors in learning need to be engaged in the multidisciplinary and sometimes trans-disciplinary research process as problem-definers, researchers, data gatherers, interpreters, and implementers.

Practice-based and Practitioner research results in actionable knowledge that leads to evidence-informed practice and knowledge-in-use. Not only the utility of the research for and its impact on practice is a quality standard, but also its contribution to existing theory on what works in practice, its validity and transparency are of utmost importance.

Context

EAPRIL encompasses all contexts where people learn, e.g. schools of various educational levels, general, vocational and professional education; organisations and corporations, and this across fields, such as teacher education, engineering, medicine, nursing, food, agriculture, nature, business, languages, …
All levels, i.e. individual, group, organisation and context, are taken into account.

For Whom

Practitioner researchers, academic researchers, teachers, teacher educators, professional trainers, educational technologists, curriculum developers, educational policy makers, school leaders, staff developers, learning consultants, people involved in organisational change and innovation, L&D managers, corporate learning directors, academics in the field of professional learning and all who are interested in improving the learning and development of praxis.

How

Via organising the annual EAPRIL conference where people meet, exchange research, ideas, projects, and experiences, learn and co-create, for example via workshops, training, educational activities, interactive sessions, school or company visits, transformational labs, and other opportunities for cooperation and discussion. Via supporting thematic sub communities 'Clouds', where people find each other because they share the same thematic curiosity. Cloud coordinators facilitate and stimulate activities at the conference and during the year. Activities such as organizing symposia, writing joint projects, speed dating, inviting keynotes and keeping up interest/expertise list of members are organised for cloud participants in order to promote collaboration among European organisations in the field of education or research, including companies, national and international authorities. Via newsletters, access to the EAPRIL conference presentations and papers on the conference website, conference proceedings, regular updates on cloud meetings and activities throughout the year, access to Frontline Learning Research journal, and a discount for EAPRIL members to the annual conference.

More information on the upcoming 2026 Conference in Cork (Ireland) can be found on our conference website http://www.eapril.org.

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European Association for Practitioner Research
on Improving Learning

FULL PAPER PEER-REVIEWED PROCEEDINGS

CHARACTERISTICS OF HIGH PERFORMING PRESERVICE PRIMARY TEACHERS IN MATHEMATICS

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ABSTRACT

This research explores characteristics and motivations of preservice teachers, who are high performing in mathematics, in Dutch primary school teacher education. While much attention is given to preservice teachers who perform less in mathematics, there is little focus on those who are high performing, despite their potential value in education. Analyses of ten semi-structured interviews indicate that preservice teachers who are high performing in mathematics often have a pre-university education, display a growth mindset, and view mathematics as a challenge. Less affluent preservice teachers tend to avoid mathematics and exhibit a more instrumental view on learning. These findings suggest that preservice teachers who are high performing in mathematics need specific support to fully develop their potential as future teachers.

INTRODUCTION

In Dutch primary school teacher education, there is much attention devoted to preservice teachers who are low performing in mathematics. This is a result of teacher education wanting to support these preservice teachers in successfully completing their education and ultimately to adequately teach mathematics in primary education. Two mathematics tests, an entrance test in the first and a mastery of the knowledge base test in the third year of teacher education, have been developed to assess preservice teachers' mathematics competences. The signal that these tests communicate is that preservice teachers who are too low performing in mathematics cannot graduate. Some teacher education institutes invest heavily in supporting preservice teachers who struggle with one of these two tests to win them over (Keijzer, 2023).

And while we observe this focus on preservice teachers who are low performers in mathematics, there is an eminent need for high performing mathematics teachers in primary education. Namely, preservice teachers who are high performing in mathematics are more prone to effectively support primary school students in learning mathematics. Low performing preservice teachers have been shown to be less successful at this. These low performing preservice teachers mainly stick to directions the mathematics textbook manual indicates. This is in contrast to what high performing preservice teachers in their mathematics teaching do. During mathematics lessons they actively engage in conversation with pupils in order to scaffold their learning (Gardebroek-van der Linde, Keijzer, Van Doornik-Beemer, & Van Bruggen, 2018).

Mathematics education generally aims at developing learners in mathematics. And because teachers who are high performing in mathematics are needed in establishing this, primary school teacher education is obliged to attract these high performing preservice teachers and retain them in teacher education. Namely, this is necessary to eventually guide these preservice teachers into becoming in-service teachers. However, there are indications that preservice teachers who are high performing in general often do not consider a career in primary education teacher as an option (Haye, 2022). Moreover, several teacher educators communicate in their network that preservice teachers who are high performing in mathematics often quickly leave teacher education before graduation, for example because they are bored, or because tasks and assignments in the curriculum do not challenge them sufficiently. However, these are general ideas held by teacher educators and in the public domain that are not yet systematically researched.
This paper takes a first, exploratory step in this direction. We explore how preservice teachers who are high performing in mathematics perceive teacher education.

BACKGROUND

Several researchers explored preservice teachers' negative attitude toward mathematics (e.g. Navarro et al., 2021). This low level of self-efficacy and attitudes toward mathematics is influenced by preservice teachers' mathematical ability (Beilock, et al., 2010) and influences their teaching (Borko et al., 1992; Nelson, 2015). However, there is hardly international research on preservice teachers in primary school teacher education who are high performing in mathematics or developed a positive attitude towards mathematics. This might be the case because primary school teachers' mathematics skills is generally not considered problematic. Limited preservice teachers' mathematics competence is considered a problem, for example in Dutch primary teacher education. In this Dutch context this is related to preservice teachers' former education (Keijzer & Boersma, 2017). Other then in the Netherlands, in most countries pre-university education (or in some countries a bachelor's degree) is required to enter primary school teacher education (OECD, 2025). In pre-university education, high level mathematics is generally included in the curriculum. Moreover, as all preservice teachers originate from similar previous education, intake in teacher education in those countries is probably less diverse than in the Netherlands. Namely, in the Netherlands many preservice teachers attended secondary vocational education or senior general secondary education, where

demands for mathematics are lower than in pre-university education. Especially preservice teachers entering teacher education from secondary vocational education often struggle with mathematics (Straetmans & Eggen, 2005). The level of these preservice teachers' mathematics skills led to investments in curricula supporting preservice teachers who are low performing in mathematics, thus helping them to develop in teacher education and finally obtaining graduation.

This focus on low performers in mathematics is more generally typical for Dutch mathematics education. There are indications that high performers in mathematics in primary education are neglected (Keijzer & Hotze, 2020; Meelissen, Hamhuis, & Weijn, 2020; Meelissen, Valk, & Maassen, 2024). The situation in primary school teacher education is not much different. Nonetheless, some occasional efforts have been made to specifically support preservice teachers who are high performing in mathematics. When this is done preservice teachers participate in separate activities or supplementary assignments appropriate to their level. For example, Marjolein Kool and Ronald Keijzer (2018) worked with preservice teachers who are high performing in mathematics from a teacher education institute in Utrecht. These preservice teachers had the task to develop a website containing mathematical problems for fellow preservice teachers, who could use the problems when practicing for the third-year nationwide mathematics test. Petra Hendrikse (2021) designed an in-depth module in geometry for her preservice teachers who are high performing in mathematics at a teacher education institute in the eastern part of the Netherlands. In this case other preservice teachers participated in a module on the same subject, but with less challenging assignments. In both cases, the high performing preservice teachers reported finding the tasks tough and needing the teacher educators' support to complete the assignments. This suggests that preservice teachers who are high performing in mathematics can be retained with punchy, challenging assignments that they can work on under the guidance of an educator.

RESEARCH QUESTION

Occasional efforts to support high performing preservice teachers in mathematics with specific assignments is not wrong, of course, but the question is whether this matches their needs or development perspective. We therefore here investigate the following research question:
What characterizes preservice teachers in primary school teacher education who are high performing in mathematics?

Answering this question asks for illuminating what typifies and motivates these preservice teachers who are high performing in mathematics in primary school teacher education (from now HP-PSTs). This needs to be contrasted with the differences with what typifies and motivates preservice teachers who are low performing in mathematics (from now LP-PSTs). To this end, we explore what typifies both groups of preservice teachers. By using the term 'typify', we hereby indicate that we are focusing on characteristics of HP-PSTs in mathematics and those typically for LP-PSTs in mathematics.

METHOD

A multiple case study fits with the exploration we envisioned (Yin, 2009). In this way, we look at what characterizes HP-PSTs in mathematics and what we observe in LP-PSTs in mathematics. We report on such a case study here, in which five HP-PSTs and five LP-PSTs participated. These preservice teachers are from different year groups. We based labelling 'high performer' or 'low performer' on their mathematics entrance test score. We characterize 'high performer in mathematics' as preservice teachers who obtained the maximum score on the mathematics entrance test. Low performers in mathematics were those preservice teachers with the exact pass mark on the mathematics entrance test, the lowest score in mathematics with which one can start in teacher education. This pass mark score corresponds to the p92 score of last year primary school students. This means that LP-PST do better on mathematics than 92 percent of the students in primary education, but perform less than the 8 percent best performing final grade primary school students.

An open interview was held with each of the ten preservice teachers, in which three themes were discussed: (1) why they chose to enter primary school teacher education, (2) how they experience teacher education, and (3) what future perspective the preservice teacher sees for himself or herself. These themes are not specifically focused on mathematics or the preservice teachers' mathematics skills. This domain specific perspective did, however, emerge in further questioning on the themes mentioned, when the preservice teacher did not spontaneously choose this perspective themself.

For example, when asking further questions on their experiences in teacher education, attention was paid to helping each other in acquiring the mathematics skills required in teacher education. In this theme, we also discussed whether the preservice teacher identified as high performer in mathematics and also whether this applied to mathematics pedagogical content knowledge (PCK) (Shulman, 1986). Concerning the future perspective, we asked the preservice teachers whether they would like to become a mathematics coordinator, if the school where the preservice teacher is employed at some stage in their professional career, asks to take this task. In addition, we asked the preservice teachers to share some background information, such as their previous education.

During each interview, the interviewer, the first author of this article, took notes. Based on these notes he composed a report. This report was submitted for approval to the preservice teacher, who could correct any inaccuracies in the report. Furthermore, the preservice teachers were explicitly given the opportunity to supplement the report if they deemed this desirable. One of the preservice teachers took this opportunity. The other preservice teachers indicated that the report they received after the interview was an adequate representation of what they shared.
The first author of this article analyzed interview reports by open labeling statements made by preservice teachers as such that a label reflects the preservice teacher's response. For example, when a preservice teacher told that she as a young child already knew that she would like to become a teacher, this was labeled as 'always wanted to work in primary education'. The labels thus constructed were next

discussed with a critical friend (the second author of this article). Alternative labels were discussed, until agreement over the labels was established.

In three steps we determined whether these labels indicate what is typical for HP-PSTs in mathematics.

- We established labels from the interview reports of the interviews with HP-PSTs in mathematics and determined which of the labels are characteristic for (almost) all of these preservice teachers.
- We established labels from the interview reports of the interviews with LP-PSTs in mathematics and determined which of the labels are characteristic for (almost) all of these preservice teachers.
- The two series of labels were compared in order to determine which labels are typical for both groups of preservice teachers and which only for HP-PSTs in mathematics.

RESULTS

High Performers

From the interviews with the five HP-PSTs in mathematics we learn that they all attended pre-university education. Four preservice teachers are studying in the regular teacher education stream and one in the part-time stream. The preservice teachers were asked why they chose to study in primary school teacher education. Four out of five preservice teachers stated in their answer to this question that they are generally interested in matters related to education.

For example, I. shared that she loves language and reading and that she would like to become a language coordinator in her future school. One of the other preservice teachers, D., stated that she has always been good at theory and that this does not apply to mathematics only, but for example also to history. Preservice teacher E. reported that she previously thought about studying biology or becoming a teacher in secondary education. However, she chose primary school teacher education because she undertook activities such as circus lessons and swimming lessons with children and liked doing so. Preservice teacher A. stated that she chose primary school teacher education because of the broad pallet of study activities. A. indicated that she enjoys explaining for all subjects and not only mathematics.

When the HP-PSTs were asked whether they also consider themselves high performers in mathematics, they agree in various terms. One of the preservice teachers does not consider herself a high performer in mathematics but does know that in the context of primary school teacher education, she is an above-average performer in mathematics. Furthermore, the preservice teachers are all aware of the fact that mathematics skills of other preservice teachers are lower than their own. This even surprises them. For example, preservice teacher C. noticed that other preservice teachers are quite stressed about the mathematics entrance test. He learned from other preservice teachers that this stress sometimes also applies to situations in teaching practice, for example when a pupil from Grade 5 asks about a mathematics

problem to which the preservice teacher is unable to respond adequately. When the interview focused on how the preservice teacher is doing in teacher education, the high performers in mathematics indicate that the theory and teaching practice stimulates them. For example, preservice teacher D. chose to attend teacher education instead of studying psychology at a research university, because teacher education is more practice-oriented. She stated that she likes that better.

In the interviews, we also talked about how the HP-PSTs in mathematics develop their mathematics PCK. They indicate that they feel to be quite strong in this, but that there is also a lot to be learned. For example, preservice teacher D. indicated that she noticed her insight into mathematics PCK in teaching in Grade 6, where she felt that she could conveniently adapt assignments to the level of the students. D. is now doing an internship in Grade 3 and 4. She indicated that she has difficulty estimating the students' level there. Four out of five preservice teachers indicate that they feel challenged when they can explain something difficult. Prservice teacher C. expressed that he is always in search of new ways to let students understand mathematics. He notices that this sometimes requires a lot of patience. He knows that he has this patience. A. indicated that she likes it when children suddenly understand something after she explained. This is especially true when students receive extended instruction. She often sees students grow there.

Three out of five preservice teachers indicate, when talking about how they experience teacher education, that they sometimes get bored. I. explained about meetings in which she wonders what the need is of what she is doing. This applies, for example, to the meetings in which she is asked, as a role play, to behave like a toddler. E. thinks very differently about this. She finds almost everything that is offered in teacher education interesting.

When, in the interview, we discussed the preservice teachers' future, after graduating from teacher education, it turns out that they had hardly thought about it. One of the preservice teachers, A., indicated, when we further elaborated on the topic, she might do something based on her experiences of the short time teaching in secondary education. E. has also not yet thought about her further development. When asked, she states that she would quite like to support her peers in passing the mathematics entrance test or become a teacher for gifted students. Generally, all HP-PSTs in the interviews indicate that they would like to support their peers when they are low performing in mathematics, and most of them do this already.

In summary, we see that these HP-PSTs in mathematics have the following characteristics:

- They have completed pre-university education, with a STEM-profile.
- They have a broad interest in the world and school subjects, and are not only focused on mathematics.
- They are aware of their own mathematics skills.
- They know that other preservice teachers' mathematics skills are less developed then their own and are also surprised by this.

- They experience teacher education challenging because it relates theory and educational practice.
- They sometimes get bored in teacher education, but certainly not always.
- They also generally feel strong in mathematics PCK, but also indicate that they still have something to learn there.
- They feel challenged when they can explain something difficult to students and explicitly look for an approach that can help a student struggling with mathematics.
- They hardly thought about what their mathematics skills can mean for their future, but they may see themselves doing something mathematics related in their future teaching practice.
- They often want to help their peers who are less affluent in mathematics.

Low Performers

The five LP-PSTs in mathematics chose primary school teacher education either because they wished to do so for quite some time or because of a recent experience in supporting pupils. For example, preservice teacher B. indicates that becoming a primary education teacher has always been a dream for her, which she is now fulfilling. This is not the case for preservice teacher L., who only came to the conclusion that the profession of primary education teacher suited her in the final phase of her former education. She helped students with homework during the Covid pandemic at the school where she was an intern. She shares how she enjoyed doing so.

In this group of preservice teachers, four consider themselves low performers in mathematics. That is different for the fifth preservice teacher we interviewed. She considers herself actually a high performer in mathematics. In her interview, her reactions and ideas differ considerably from those of the other LP-PSTs. We therefore consider this preservice teacher separately first and then discuss the other preservice teachers.

Preservice teacher M. sees herself as a high performer in mathematics. She has completed secondary vocational education before entering teacher education. M. indicates that in primary education she did not flourish in mathematics, but in pre-vocational secondary education she suddenly understood what it was about: ‘In secondary education I noticed that I could do it. Then you develop yourself further.' In teacher education she shows enthusiasm for research assignments, for example in mathematics classes. She says she enjoys mathematics in teacher education. This is especially true for the assignment ‘Mathematics in the news’, where preservice teachers are asked to come up with an open assignment for preservice teachers in response to a recent media report (Stuber, Veldhuis, & Keijzer, 2021). M. articulates her contribution to children's mathematics learning well. For example, she talked about how she helps a student in Grade 6 who is doing mathematics at Grade 3 level. M. has thought about her future and sees herself doing something related to mathematics. For example, she would apply if a teaching assistant in mathematics vacancy arises in teacher education and would like to become a mathematics coordinator if the school where she will work later asks her.

The other four preservice teachers in the group of LP-PSTs in mathematics do not consider themselves high performers. For these preservice teachers, three are from secondary vocational education and one has senior general secondary education as a previous education. One of the preservice teachers, Z., explains that mathematics went well in senior general secondary education, but she now finds mathematics difficult, in particular when it asks for mental calculations or reasoning with fractions. Three out of these four preservice teachers sometimes find teacher education boring. For example, preservice teacher S. wonders ‘What am I doing here?’ when attending specific meetings. Z. sometimes experiences teacher education as boring because she is already familiar with the subjects at stake: ‘I learned mathematics in primary school. And reading aloud, which is central to Dutch, I do regularly.' Preservice teacher B. feels that teaching in teacher education could often be more efficient. All of these four preservice teachers indicate that they expect teacher education to prepare them efficiently for teaching practice only.

This idea of training goes along with showing an instrumental image of what education should be. This involves the idea these preservice teachers have of explaining as precise demonstration and the idea that one learns through repetition. For example, preservice teacher F. complained about the support she received while working on the mathematics entrance test, as it was focused on understanding. She took tutoring where she practiced a lot. L. shows a similar idea of education when explaining about her further development for mathematics, which she definitely considers necessary: ‘I notice that it doesn't stick. Therefore, I have to repeat a lot.'

The LP-PSTs, according to the entrance test, who do not consider themselves high performers in mathematics, respond in different ways to the question whether they see their development related to mathematics teaching. In general, these preservice teachers indicate that they have little or no desire to develop further in this subject. Preservice teacher L., does not completely rule this out when she may have developed quite a bit later on. Preservice teacher F. indicates that she may want to become a special needs teacher later on. When in the interview the suggestion came forward that she might be asked to become a mathematics coordinator, she responded vehemently: ‘I'm really not going to do that. I think mathematics is terrible.' She added that she might want to become coordinator for the higher or lower grades.

All LP-PSTs in mathematics who do not consider themselves high performers in this subject indicate that their limited mathematics skills are reasons for them to reject teaching in the higher grades. Also in their internship they try to avoid teaching in higher grades. Preservice teacher L., for example, stated in this regard: ‘I have never taught a class higher than Grade 3 or 4.’

Summarizing, we see that for the LP-PSTs in mathematics who do not consider themselves high performers, the following characteristics emerge:

- They come from secondary vocational education or, in one case, senior general secondary education.
- They consider their subject teaching skills for mathematics to be good.

- They show an instrumental view of education, namely explaining is exactly showing and learning is done by repetition.
- They do not clearly articulate what they can contribute to students' learning.
- They expect education to prepare them mainly or purely for teaching practice.
- They generally have no desire to develop further for mathematics.
- They prefer not to teach in the highest grades because they have insufficient mathematics skills to do so.

In the case of the preservice teacher who is a low performer, as measured by the entrance test, and considers herself as high performing in mathematics, we see a different picture. This preservice teacher indicates that in primary education, she was unable to develop mathematical understanding. Now, many years later, she is stimulated by research assignments in teacher education, including in mathematics. She can also articulate her contribution to students' learning in mathematics. She has thought about her future and sees herself doing something that requires development in or for mathematics.

Combining Characteristics

We compare what characterizes HP-PSTs in mathematics with what characterizes low performers. When we do so, we observe that HP-PSTs in mathematics have a different background in secondary education as compared to their low performing peers. They come from pre-university education, while LP-PSTs in mathematics generally have a background in secondary vocational education. This is in line with previous findings concerning preservice teachers' mathematics skills (Keijzer & Boersma, 2017). We see that preservice teachers in both groups consider themselves good in teaching mathematics. However, HP-PSTs in mathematics generally better substantiate their mathematics PCK skills. Furthermore, preservice teachers in both groups expressed the wish to work with children and have often had had this desire for quite some time. Preservice teachers in both groups sometimes get bored in teacher education, but preservice teachers who consider themselves low performers in mathematics are more outspoken about this. They get bored because they expect teacher education to instrumentally prepare them for teaching practice only.

When looking at the differences between the two groups of preservice teachers, we see it is worthwhile to distinguish between those preservice teachers who consider themselves high performers in mathematics and those who think they are not. The latter group seems to have an instrumental view of teaching, where in contrast, preservice teachers who consider themselves as high performers present teaching mainly as searching for an appropriate approach in order to stimulate students' development. Preservice teachers who consider themselves as high performers see themselves developing further in mathematics and if they do not, it is because of personal preferences. Preservice teachers who see themselves as low performers in mathematics indicate that they see little or no such development for themselves.

TENTATIVE CONCLUSION AND DISCUSSION

In this paper, we explored what typifies high performers in mathematics in primary school teacher education. We see that these HP-PSTs in mathematics have several characteristics that are common to all preservice teachers. This applies, for example, to the desire to work with students. For many preservice teachers, this appears to be a wish they have cherished for quite some time.

We further see that all preservice teachers are experiencing teacher education sometimes as boring, but that this is more common among students who do not rate their own mathematics skills highly. This may be related to their perception of learning, namely that they think learning is instrumental in nature and that the role of teacher education is to prepare them purely efficiently for teaching practice. HP-PSTs in mathematics generally do not get bored, as previously thought, but seek challenge in teaching mathematics and support students herein. They outline helping students as a puzzle to find an appropriate approach. Furthermore, HP-PSTs in mathematics indicate that teacher education usually is not boring. This is also true for the preservice teacher who is a low performer but considers herself high performing in mathematics. Preservice teachers who consider themselves low performers in mathematics look for ways to avoid using their mathematics skills, for example by explicitly not choosing to teach in the highest grades of primary education. Teacher education is boring for them, if it offers them more than practical preparation for teaching practice.

We thus may tentatively conclude that preservice teachers who do not rate their mathematics skills as ‘strong’ have several characteristics commonly referred to as a fixed mindset. This is not true for preservice teachers who consider themselves as high performing in mathematics. These preservice teachers mainly show a more growth mindset (Boaler, et al., 2021). Preservice teachers with a growth mindset believe that they, as well as the students they teach, can grow, whereas preservice teachers with a fixed mindset see knowledge as a static entity that does not develop. Teachers with a growth mindset know how to excite students - especially in mathematics lessons. The small-scale exploration of the perspective of teachers who are high and low performing in mathematics described here suggests that possibly preservice teachers who rate their mathematics skills as ‘high’ exhibit more of a growth mindset.

These tentative conclusions are based on exploring preservice teachers’ ideas in only a limited number of interviews with these preservice teachers. And although the preservice teachers are likely to be typical for the group of high and low performers respectively, follow-up research is needed to further investigate the findings described here. That being said, this exploration already offers several clues for nurturing high performers in mathematics in primary school teacher education, namely providing them with challenging tasks on the edge of educational theory and teaching practice.

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GAINING POWER IN A CHANGE LABORATORY WITH ADOLESCENT STUDENTS

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ABSTRACT

This study explores how adolescent students generate and gain power through object-oriented collective activity in Change Laboratory within schools. Drawing on cultural-historical activity theory, the focus is on the significance of an object for which power is needed. We invited adolescents to create projects which connect their personal interests with the quest for a just and equitable world. Fourteen eighth graders participated in a Change Laboratory (CL) intervention to create projects significant to them. This study focuses on a Documentary Project about bullying and acceptance, created by four students during the CL intervention conducted in school over one academic year. CL sessions took place during regular school hours, allowing students to choose, design, and implement project topics, contents, and means without the constraints of the curriculum and the pressures of testing and grading. The recorded data were transcribed and analysed using qualitative methods. The findings indicate that gaining power is a complex and longitudinal process shaped by multiple factors. A key insight is the notion of object-oriented power, which is associated with the meaningfulness of the educational experience and fosters significant learning opportunities.

INTRODUCTION

The paradox of control and autonomy is a fundamental contradiction in education (McNeil, 1988; Rainio & Hilppö, 2017). In practice, this paradox presents a dual need for both control and order, on one hand, and for nurturing and fostering students' participation, individual aspirations, and interests, on the other. This contradiction has been considered insurmountable and has been identified as the primary barrier to the evolution of school practices in the Finnish context (Salminen, 2012). The concept of power is closely intertwined with the notion of control as the notion of autonomy to the concept of agency.

The notion of agency has rapidly become a central focus in educational research (Engeström et al., 2022), receiving considerable attention in the literature on youth studies, as well as the notion of power (Spencer & Doull, 2015). However, these authors have observed a relative lack of discussion regarding how the concept of agency is interconnected with and supported by the concept of power. According to them, understanding agency is inseparable from considering the concept of power. Engeström et al. (2022) assert that the definition of agency actually refers to the ability, condition, or state of taking action or exerting power. Spencer and Doull (2015) argue that agency cannot be comprehended without taking into account the concept of power. Furthermore, Rodriguez (2013, p. 103) highlights that "power and agency exist not only in the ability to act with purpose on one's behalf but also in the acts themselves and in being able to communicate the possibility (or even threat) of action".

As Esmonde and Booker (2017) argue, the presence of power in learning environments is a constant factor, and therefore, any successful learning design must consider its influence. The issue of power is especially significant in schools when educating minors. Power dynamics in settings involving adolescents can significantly affect their ability to contribute professional expertise, and social status often overshadows their input, limiting their meaningful participation (Jadallah et al., 2024). The process of learning entails active participation and is, in fact, dependent on it (Moje & Lewis, 2020). Furthermore, power relations have implications for who learns, what is learned, and how learning takes place (Esmonde and Booker 2017). In other words, the importance of power in school settings is crucial.

The issue of adolescents' well-being and engagement in schooling is widely discussed in public forums. The study addresses major concerns surrounding these challenges in education worldwide, including issues with school attendance, lack of enthusiasm for education, and the prevalence of mental health problems among youth. However, in the educational context, students are often viewed as mere providers of information, rather than active initiators and decision-makers. They are seldom given opportunities to express their voices in the school context (Bjarnadóttir & Geirsdóttir, 2018). In schools, adults typically hold positions of power (Bertrand et al., 2020), and students often perceive power as a form of control wielded by adults (Feldman & Marshall, 2020). Traditional views of power often remain possessive, hierarchical, and static (Simeneova et al., 2024).

The existing body of academic literature on power generation appears to be limited. However, certain researchers have delved into the generative dimension of power. For instance, Tivaringe and Kirshner (2021) conducted a longitudinal study on how members of youth-led organised groups in South Africa learn to build power within the sociopolitical context. Their research revealed that support from experienced peers in environmental education facilitated young people's understanding of inequality, leading to their engagement in nonviolent political activism. The study highlighted how these young individuals formed alliances with trade unions and community elders to claim power and influence political change, contributing to the

literature on youth activism by demonstrating how they navigate politics and exert power through intergenerational alliances.

This study draws on cultural-historical activity theory (CHAT), a theoretical framework that emphasises the object of activity as the central force driving the meaning and purpose of the activity (Engeström, 2015). It is worth noting that CHAT has faced criticism for its limited analytical tools in studying broader power systems (Esmonde, 2016). Although there are exceptions (see e.g. Choudry, 2023), the concept of power has not been a primary focus within the CHAT context (Simeneova et al., 2024).

Nevertheless, Sannino (2023) introduced the notion of power as a productive emancipatory force, often hidden, unrecognised, and suppressed, yet still generated in various ways. Agency, when viewed as a transformative process, fundamentally embodies a form of power that emerges through the efforts of individuals and collectives striving to effect necessary change. In TADS model (transformative agency by double stimulation), power entails the intentional exercise of control over oneself and specific aspects of the activities one participates in (Sannino 2022). Gradually, this can build collective momentum and ultimately have an impact on the wider political and economic landscape. Sannino's (2023) work presents a power-sensitive concept of transformative agency, emphasising that power can be activated through the utilisation of TADS. Conflicting motives serve as a vital resource for both the generation and exercise of power. Furthermore, power is a deliberate process that can be initiated and sustained by the intentional mobilisation of material and symbolic artifacts as mediator.

According to CHAT, power is closely linked to the object of an activity, the fundamental element within this framework (Foot, 2001). The CHAT perspective emphasises the importance of identifying an object for which power is required rather than solely seeking freedom from control. Empowering students cannot be achieved merely by eliminating or reducing control. Instead, an alternative to adults' controlling role in school is to identify an object that students find meaningful to aim for. Taking a step towards this requires authorising students as owners of their own learning.

The research project aimed to resolve this contradiction of control and autonomy by inviting a group of adolescent students to work on issues they find significant. The aim was to facilitate a process in which the students could identify, select, and work on an object that they find significant, not only for themselves but also for others and possibly for society at large. Students were assisted by researchers, school staff, external experts, and other key stakeholders as needed. We assumed that such a collective process will generate power, manifested as initiatives and decisions taken by the students themselves.

In summary, this study investigates how adolescent students generate and gain power through object-oriented collective activity in the school setting. This approach offers adolescents the chance to create projects on topics that are important to them and

potentially to society at large. The research questions that drive this study are as follows:

1. How do adolescent students produce initiatives and make decisions within a student-led project in a Change Laboratory intervention?
2. How is power generated within a student-led project in a Change Laboratory intervention?
3. How does a student-led project in a Change Laboratory intervention serve as means of expansive de-encapsulation of school, and how are actions of de-encapsulation related to the power-gaining of adolescent students?
4. What actions did adults take during the student-led Documentary Project in the Change Laboratory, and how were these actions related to the power-gaining of adolescent students?

RESEARCH SETTING

This study employs a Change Laboratory (CL) formative intervention, a participatory analysis and design method based on cultural-historical activity theory and the theory of expansive learning (Sannino & Engeström, 2017). This method has been utilised in 30 countries across educational institutions, workplaces, and communities to generate bottom-up solutions to challenging problems and complex transformations (Sannino & Engeström, 2017). While CLs have been extensively used in educational settings, the participants have predominantly been teachers (Hopwood, 2024). Notably, the CLs in this study marked the first instance of placing adolescent students as central agents to redesign their activities by creating significant projects (Hopwood, 2024).

The CL intervention method was selected to confront power dynamics in the school environment, particularly the traditional power imbalances between teachers and students (Rodriguez, 2013). In the CL intervention process, participants take charge of the learning process, as illustrated in Engeström et al.'s study (2013), in contrast to the typical school environment where students have limited control over their own learning (Bjarnadóttir & Geirsdóttir, 2018; Kiilakoski, 2017). We hypothesised that the CL method could help change the imbalanced power relationship by emphasising the central role of students.

The CL intervention was carried out in a comprehensive school in Finland during 2020-21 school year (Engeström et al., 2023). Fourteen eighth-grade students voluntarily participated in the CL intervention to create projects meaningful to them. As a part of the ethnographic phase of the CL, our research group conducted interviews with students, school staff members, and external school partners.

The CL sessions took place during regular school hours and in a school space, allowing students to freely choose, design, and implement project topics, contents, and means without the constraints of the regular curriculum and the pressures of testing and grading. At the end of the CL, public closing events were held in a hybrid setting. Final interviews with students, school staff members, and external experts were conducted after the interventions. Altogether, students produced five different

projects. This study focuses on a Documentary Project titled "*Everyone should be accepted as one is"* about bullying and acceptance.

Equality, bullying, and diversity were important themes for the members of the Documentary group. They had seen or experienced themselves bullying, prejudices, racism, and inequality at school, in their leisure time, and on social media platforms. They felt that everyone should understand that it is not okay to bully or exclude other people. But it is difficult to intervene without becoming bullied, excluded or even subjected to violence.

The group decided to create a documentary film. It would feature dramatised scenes of bullying, including perspectives from both the perpetrator and the victim, as well as interviews with individuals who have experienced bullying or discrimination. The group began planning the manuscript and recruiting interviewees and actors. Researchers found a documentarist who worked with the students in three CL sessions.

The work of the Documentary group was objectified in the form of a 10-minute documentary film "Everyone should be accepted as one is", which was filmed in school during two school days. Other students from the school acted in the film. The group conducted interviews in the school. The documentary was shown at the public closing event of the project, in their own school and in other schools, and was freely shared on a website with Finnish and English subtitles. Figure 1 presents the timeline of the Documentary Project.

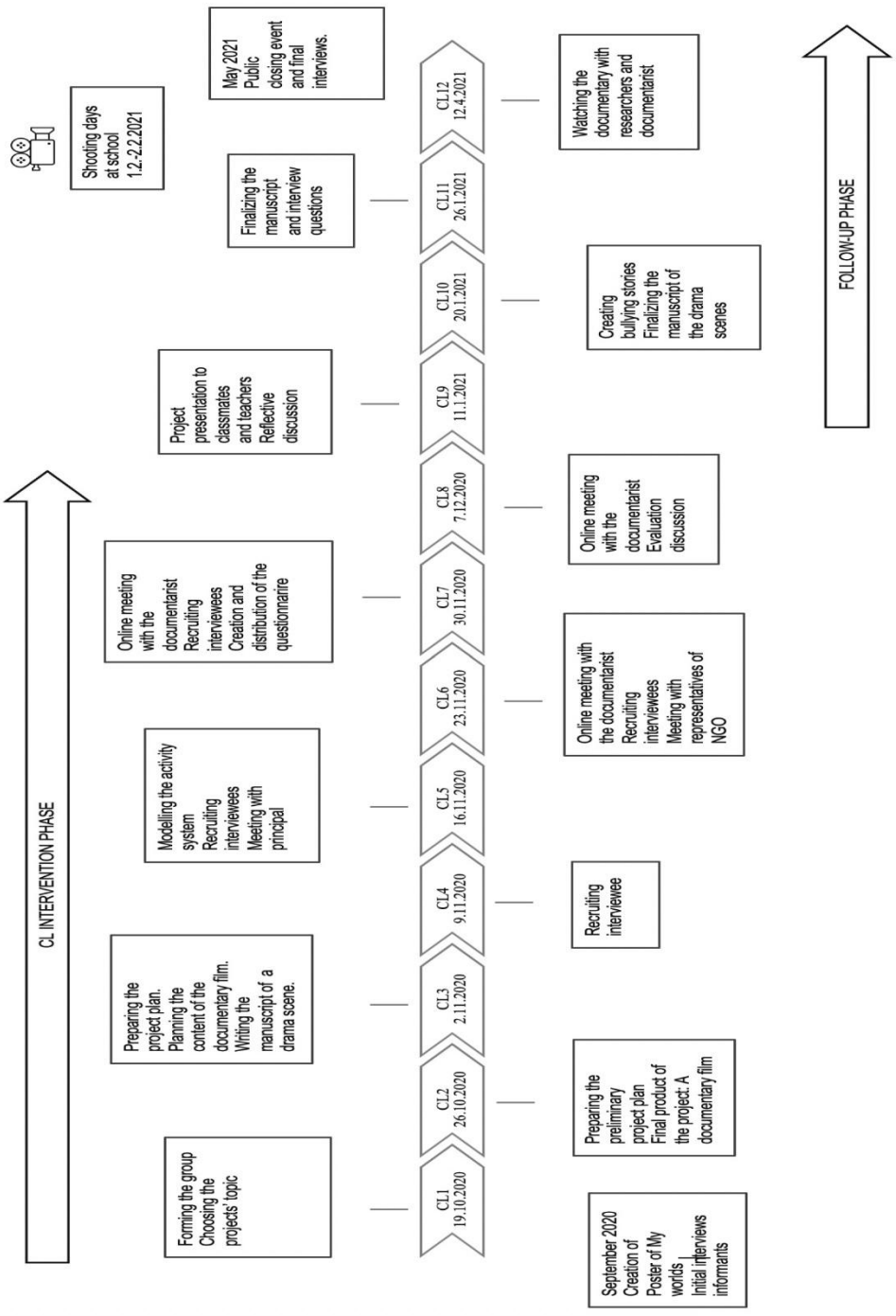

Figure 1. *Timeline of Documentary Project*

DATA AND ANALYSIS METHODS

The data of this study consists of recordings of CL sessions (n=8) and follow-up sessions (n=4) concerning the Documentary Project. The data was transcribed verbatim by a professional transcriber. In addition to the recordings, supplementary materials such as researchers' field notes, emails, and text messages were used for analysis to locate actions taken outside the CL sessions.

This research follows the tradition of formative intervention studies, involving a comprehensive analysis of the entire intervention process, including detailed data analysis to uncover the epistemic and interactional dynamics (Haapasaari, 2020). The study encompasses four distinct analyses conducted independently, as well as combinations of these four analyses. Below, I outline each step of the complete analysis process.

The preliminary phase of all empirical analysis was conducted during the CL intervention process. CL intervention unfolds according to its participants and is shaped by their perspectives. After each session, the subsequent session was planned based on the content of the previous session. During the CL, I reviewed the recordings of CL sessions immediately after each session and created intervention logs for each session. Before and after each session, our research group held meetings to discuss the session and plan the next one. Additionally, I wrote field notes after each session, as did two other researchers, and these field notes were shared among us.

An empirical analysis of initiatives and decisions was conducted as the foundation for further research, building on previous work about suggestions (Teräs, 2007) and initiatives (Haapasaari, 2020). The focus was on generating initiatives and forming initiative paths (Haapasaari, 2020). An examination of transcripts revealed that existing methods could not be directly applied. Instead, the analysed data led to the development of a new analysis method. After defining *initiative* in the context of the documentary film, 38 initiatives were identified based on their content and how they emerged in social interactions.

The research's longitudinal design and concise final product offered a methodological advantage in studying the development and evolution of initiatives throughout the CL intervention. The 38 identified initiatives formed the basis for analysing initiative paths. Each of these paths originated from one of the 38 initiatives, referred to as the *opening initiative* for clarity. The subsequent steps of these opening initiatives were then investigated. A thorough examination was conducted for each speaking turn, and every expression discussing the initiative formed a link in the initiative path. Four types of initiative paths were identified: *Contained path*, *Chain, Cluster,* and *Micro-path*.

In the course of this analysis focusing on initiatives, it became necessary to create a separate category for students' discursive expressions, named *preambles*. *A preamble* is an expression through which students articulate their opinions, viewpoints, observations, analyses, statements, and personal experiences pertaining to the project

themes, such as bullying, equality, diversity, and the acceptance of others. While preambles did not directly fulfill the criteria for initiatives, they were found to be essential building blocks for initiatives.

Next, a detailed analysis concerning power was pursued. The discursive actions exemplifying students' power were analysed. For conducting this analysis, three distinct steps were taken: 1) An analysis of discursive actions exemplifying students' power; 2) Connecting initiative paths (see the preceding section) with discursive actions exemplifying students' power; and 3) An analysis using the TADS model as a framework.

This study presents a new methodology for examining the discursive actions exemplifying students' power. The need for this methodological framework stemmed from practical concerns, as we found no existing framework capable of systematically analysing manifestations of power. The initial step involved a thorough review of the transcripts to identify expressions that exemplify students' power (i.g, Jadallah et al., 2024), utilising both theoretical and data-driven approaches. Through a systematic review, six types of discursive actions exemplifying students' power were identified.

After that, the transcripts were divided into conversational episodes based on their substantive content, which were then categorised into main and sub-themes. A discursive action was identified on the basis of (a) discerning the conversational episodes based on their substantive contents, (b) analysing the turns of talk within each episode in terms of discursive actions, and (c) specifying the function of each type of discursive action, using the framework of the six types of discursive actions Throughout this phase, discussions were held with other researchers regarding different types of discursive actions and the criteria of identification based on a representative data sample. Identification criteria for each type were finalised through shared discussion until consensus was achieved. During this phase, the final six types of discursive actions exemplifying students' power were established: 1) Taking ownership of the process; 2) Committing to take concrete actions; 3) Claiming ownership; 4) Expressing knowledge and competence; 5) Recognising one's own progress; and 6) Taking transgressive action.

A segment of the transcript was coded and reviewed by another researcher, achieving a 72% initial agreement. Discrepancies were resolved through discussions, and a 10-page segment was double-coded for consistency. Challenging actions were reviewed to ensure inter-coder agreement, and data was checked for consistency. Then, two empirical analysis of initiatives and decisions and discursive actions exemplifying students' power were combined.

Finally, the augmented TADS model (Sannino, 2022) was employed to illustrate how students generate and gain power through their initiatives and decisions. The augmented TADS model used in this study comprises the following steps: 1) Raw object; 2) Conflict of motives; 3) Search actions; 4) Second stimulus; 5) Finding traction; 6) Real conflict of motives and 7) Implementation as objectification and expansion.

In this analysis, by employing the augmented TADS model, a comprehensive examination was conducted to explore the roles of preambles, initiative paths, and decisions within the TADS process, understood as a process of generating agentive power. These elements were systematically categorised and situated within each step of the model.

As a third step, an analysis of expansive de-encapsulation actions was conducted, using the method developed by Engeström et al. (2023). Additionally, an examination of object formation was undertaken, drawing upon the frameworks presented by Engeström et al. (2016) and Rantavuori et al. (2016). Through iterative reading of the transcripts, I identified different phases and turning points (Rantavuori et al., 2016) in the process of object formation. Additionally, I explored the expansion of the object on three dimensions: socio-spatial, temporal and ethical-political (Engeström, 2000; Engeström et al., 2016). Ultimately, the two analyses, namely that of expansive de-encapsulation actions and that of the object formation process, were integrated to gain a more comprehensive understanding of expansive de-encapsulation of the school.

As a fourth step, a data-driven analytical procedure was developed to examine adults' actions in a CL involving adolescent students. The initial phase of the analysis involved reviewing transcripts to understand these actions, leading to the identification of six types of adult actions. The next step involved selecting representative samples and formulating criteria and names for the different types of adults' actions. In this phase, two additional types of adults' actions were identified, resulting in the identification of eight types of adults' actions: 1) Asking questions and making suggestions; 2) Respecting students' ownership; 3) Providing encouragement and positive feedback; 4) Enabling and providing concrete help; 5) Reinforcing students' ideas; 6) Giving instructions; 7) Co-planning; and 8) Taking restrictive action. The subsequent phase involved dividing the transcripts into conversational episodes, which were then categorised by main and sub-themes. The adults' actions during the intervention were classified according to the types identified in the previous phase of analysis. The types of adults' actions were then counted in each session.

OVERVIEW OF THE KEY FINDINGS

This section presents key findings in response to the research questions. The first research question examined how adolescent students produce initiatives and make decisions in a student-led project within a CL intervention. This study identified a group of expressions titled *preambles*, encompassing students' strong opinions, observations, analyses, and their own experiences related of the project topic. Preambles appear to play a crucial role in the initiative-taking process: while they did not fully meet the criteria for an initiative, they served as essential building blocks for the initiatives. It was observed that generating initiatives requires discussion and collaborative effort on the topic, rather than occurring effortlessly, as selecting a product from a retail shelf does. Furthermore, seven types of initiative generation in social interaction were identified. These variations illustrate that there is no singular approach to taking initiatives.

The findings emphasise the significance of time and support in the empowerment of adolescent students. Time was needed to identify a meaningful object, and then to give shape to the object and work on it. It can be challenging (Vare & Bursch, 2024), but of utmost importance in the power gaining process. The emergence of preambles before the material product of the project was chosen, highlights the importance of exploring and defining the project topic, posing questions such as: What are the things I am interested in? What actually is the topic we want to work with and why? What contents are included in the chosen topic, and what could be the final product of the project? This aligns with Sannino's (2023) point that the specific issue can be modified during the learning process and is an essential part of it.

In a multifaceted and extensive process such as this, initiatives created paths. Four types of initiative paths were identified: *Contained path, Chain, Cluster,* and *Micro-path.* Results signify the ambitious and challenging nature of the students' project, which involved multiple steps and elements requiring various types of initiatives and complex decision-making abilities. It draws attention to the diversity of initiatives and their relevance to pedagogical practices within schools. Moreover, especially *Chains*, *Clusters*, and *Micro-paths* exhibit features of "third space" learning (Gutierrez et al., 1995), indicating the intentional fostering of the creation of such a space within the school context. This underscores the importance of appreciating students' initiatives, beginning with their autonomy to choose the project's focus and lead their own learning process.

The results reveal that students were allowed to make decisions and were capable of making those decisions. This study identified five distinct decision-making processes: 1) Negotiated decisions; 2) Decisions emerging during the initiative; 3) Decisions nested in other decisions; 4) Decisions nested in other decisions; 5) Individual decisions made by a single person.

The second research question aims to investigate the generation of power among students. The empirical findings of this study identified six types of discursive actions exemplifying students' power: 1) Taking ownership of the process; 2) Committing to take concrete actions; 3) Expressing knowledge and competence; 4) Claiming ownership; 5) Recognising one's own progress; and 6) Taking transgressive actions. The fact that the analysis identified six different types of discursive actions exemplifying students' power is significant in itself. It indicates that having power can appear in several ways. Notably, in CL session 1, the five types of discursive actions exemplifying students' power appeared, of which expressing knowledge and competence was the most frequent.

In this study, the interest is on the process of generation of students' power. Figure 2 illustrates how the six types of discursive actions exemplifying students' power evolved over the course of the CL intervention.

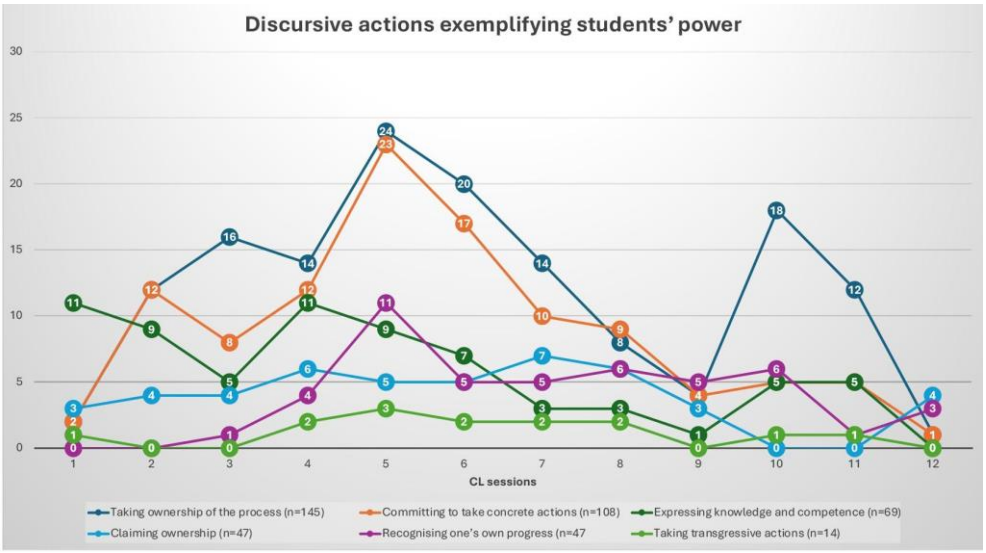

Figure 2. *The Evolution of Types of Discursive Actions Exemplifying Students' Power Over the Course of the CL*

Figure 2 shows that the evolution of the two most frequent types of discursive actions, namely *Taking ownership of the process* and *Committing to take concrete actions,* went largely hand in hand except the sessions 10 and 11. The category of *Expressing knowledge and competence* is more frequent in the first six sessions. Notably, in session 1, there are 11 discursive actions of expressing knowledge and competence, which is clearly the most frequent type of discursive action. It can indicate the importance of the chosen topic of their project. It seems that in this process, the starting point for the generation of power was the possibility to express the existing knowledge and competence group members had of their topic, the object of their activity.

Taking transgressive action is a particularly intriguing type of discursive action that exemplifies students' power. It is particularly interesting regarding the context of this study, which aimed to provide students as much power and autonomy as possible. Interestingly, transgressive actions began in CL session 1, being highest in CL session 5 and continuing till the CL session 11. It indicates that the so-called given power, defined by someone else, is not enough.

The in-depth analysis of the evolution and emergence of discursive actions exemplifying students' power throughout the CL intervention revealed that power is a longitudinal process, increasingly manifesting through discourse as the project progressed, illustrated in Figure 3.

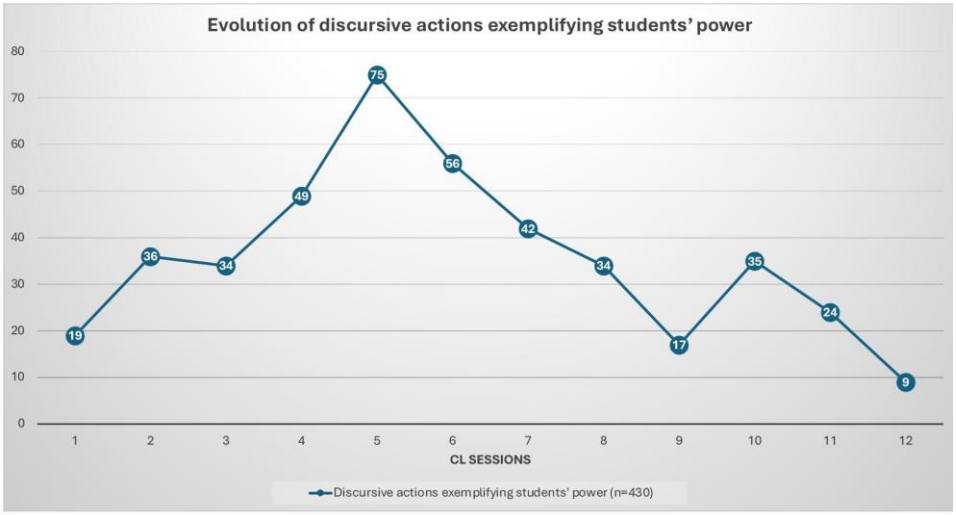

Figure 3. *The Evolution of Discursive Actions Exemplifying Students' Power Over the Course of the CL*

The findings of the combination of analysis of initiatives and decisions and discursive actions reveal that initiative paths were related to discursive actions. It was found that each of the initiative paths included discursive actions exemplifying students' power, with the number of such actions ranging from one to 50. CL method enabled and facilitated students to take initiatives and make decisions, which is unconventional in the context of schooling at this level (see i.g. (Bjarnadóttir & Geirsdóttir, 2018). Through these initiatives and decisions, students generated and gained power.

The integration of empirical analysis concerning students' preambles, initiatives, and decisions into the augmented TADS model establishes a robust framework for understanding how students generate power. This study demonstrates that students' preambles, initiatives and decisions serve as means of gaining power. The findings underscore the distinct roles these elements play in the process of gaining power at each step of the augmented TADS model. Preambles are crucial for formulating the raw object and articulating the conflict of motives, while initiatives defined as search actions significantly contribute to constructing the second stimulus.

Additionally, students' various decisions help sustain this second stimulus. Initiatives following the second stimulus emerge as a key step in the practical implementation of the project, further promoting its development. Two initiative paths represented the next step in the augmented TADS model: the real conflict of motives. These paths related to the realisation that we are either able to produce the documentary with our own resources or need external help. The final step of TADS model: Implementation as objectification and expansion, encompasses initiative paths focused on practical elements aimed at completing the documentary film. These initiative paths commenced immediately after the second stimulus and continued throughout the intervention.

Building on Sannino's TADS model (2022), this study has developed and implemented a seven-step framework to describe and analyse how students gain power through their initiatives and decisions. The augmented TADS model provides a valuable framework for describing and theorising the stepwise process of power generation among students. It enhances our understanding of the power-gaining process and demonstrates that initiatives and decisions are instrumental for students to gain power through object-oriented collective activity in the CL intervention. The TADS framework effectively illustrates the mechanisms by which power is generated and outlines the stepwise process of gaining power. These findings confirm that CL served as a platform through which students could generate and gain power by means of initiatives and decisions.

The third research question asked: How does a student-led project in a Change Laboratory intervention serve as a means of expansive de-encapsulation of school, and how are actions of de-encapsulation related to the power-gaining of adolescent students? The study revealed that a rich and continuous number of de-encapsulation actions (n=44) were taken in the Documentary project. These actions encompassed all four directions, involving movement both within and outside the school, and were executed by individuals, groups, and organisations. Expansive de-encapsulation actions were vehicled through the movement of people, text/talk, and imagination. Findings revealed that the Documentary project emphasised movements related to the outside world. Notably, the groups successfully engaged a considerable number of individuals from within and outside the school, effectively opening the school to the outside world and bringing the outside world into the school.

The findings suggest that the expansive de-encapsulation actions stemmed from the object of activity, driven by the need to resolve the conflict of motives experienced in personal encounters with bullying and discrimination. These conflicts of motives were critical to the students' choice of project focus. Their project was not randomly chosen; rather, it was carefully selected to address these underlying conflicts of motives. To resolve the conflict of motives, an emancipatory object was created through six steps, leading to the anticipated tangible outcome of a documentary film. Expansive de-encapsulation actions truly began only afterwards. The de-encapsulation actions undertaken by the students thus originated from the object of the activity. Engaging in expansive de-encapsulation actions involving people and organisations outside the classroom created further opportunities for generating power.

The study aimed to investigate the impact of allowing students to engage in meaningful projects by giving them autonomy to choose their own topics. The key findings of this study underscore the relationship between power and expansive de-encapsulation actions. The exploration of these meaningful objects led to an expansion of the school's boundaries. Furthermore, these actions not only facilitated the opening of the school but also played a crucial role in the process of students gaining power. By participating in these collective actions, which included planning, implementing, and reporting, the students created opportunities to generate and gain power. Their active involvement in expansive de-encapsulation actions allowed them to learn firsthand how to influence issues that mattered to them. Thus, de-

encapsulation served as a mechanism through which students could utilise this generated and gained power in pursuit of their object of the activity. Ultimately, expansive de-encapsulation actions contributed to opening up the school and became a key way to generate and gain power. It appears that without these expansive de-encapsulation actions, generating and gaining power on such a large scale would not have been feasible.

The fourth research question asked: What actions did adults take during the student-led Documentary Project in the Change Laboratory, and how were these actions related to the power-gaining of adolescent students? In this study, eight distinct types of adult actions were identified across the project, as Table 1 illustrates.

Table 1. *Adults' Actions in the Documentary Project Across CL Intervention*

CL Session	AQMS*	RSO	EPCH	GEPF	RSI	GI	CP	TRA	(n)
1	15	9	5	9	6	10	0	2	56
2	23	16	4	6	14	8	0	1	72
3	14	18	10	11	18	5	3	2	81
4	13	6	14	11	2	7	0	4	57
5	29	22	26	10	13	5	1	4	110
6	18	31	29	15	14	7	3	8	125
7	12	17	21	8	3	10	4	2	77
8	19	10	9	10	7	7	5	5	72
9	6	4	6	4	4	1	0	0	25
10	4	8	2	6	2	4	13	0	39
11	4	8	6	6	3	1	9	1	38
12	4	8	5	5	0	0	0	0	22
Total (n)	161	157	137	101	86	65	38	29	774

*AQMS = Asking questions and making suggestions, RSO = Respecting students' ownership, EPCH = Enabling and providing concrete help, GEPF = Giving encouragement and positive feedback, RSI = Reinforcing students' ideas, GI = Giving instruction, CP=Co-planning, TRA=Taking restrictive actions

During the 12 CL sessions, adults performed 774 actions, primarily asking questions and making suggestions (n=161), followed by respecting students' ownership (n=157), and enabling and providing concrete help (n=137). The fewest actions involved taking restrictive actions (n=29). The findings regarding these actions indicate that their primary objective was to support students in gaining power over their learning and breaking down the barriers of traditional schooling. In essence, the adults' actions focused on supporting the students' projects.

However, the findings also revealed instances of adult actions that hindered the process of students gaining power particularly in the form of taking restrictive actions. The category “restrictive action” illustrates that traditional schooling is not easy to change (i.g. Artiles, 2011) even in this kind of intervention, which addresses students' autonomy. On the other hand, students' transgression became visible in the analysis of adults' *Restrictive actions*. It indicates that more than “given power” is needed for students. They found it necessary to “take power” to be able to work with their project in the way they planned. Overall, findings highlight the importance of a wide range of adult actions in facilitating the students' power-gaining process.

DISCUSSION AND CONCLUSION

At the outset of the paper, I highlighted the research gap concerning the relationship between the concepts of agency and power. Building on the findings of this study and assertions put forth by Sannino (2023b), I introduce the concept of object-oriented power, developed through this research. When comprehended in this manner, the notion of 'object-oriented power' effectively serves as a mediator connecting power and agency. The pivotal findings of this study led to the formulation of the concept of object-oriented power. Drawing from the empirical and theoretical findings of this study, it is evident that gaining power is a multifaceted, gradual process involving numerous elements and contributors. In summary, the definition of object-oriented power can be outlined as step wise process:

(1) Power should be grounded in the genuine needs and conflicting motives;

(2) Power must be directed toward and built upon a specific object;

(3) The power of an object stems from its ability to address conflicting motives;

(4) Identifying a meaningful object can be challenging and time-consuming, thus it should be supported;

(5) Merely selecting the object is not sufficient as it only signifies the beginning of the process of generating and gaining power;

(6) Gaining power is a process that requires instruments, such as initiatives and decisions;

(7) Generating and gaining power is a collective endeavour;

(8) The process of gaining power entails reaching out beyond the original participants and crossing one’s own boundaries.

This research contributes to CHAT by examining power dynamics within schools (Simeneova, 2024), and by offering analytical tools for examining power (Esmonde, 2016.) It demonstrates how power can be analysed through the augmented TADS model (Sannino, 2022). The findings hold practical implications by introducing the

concept of object-oriented power, outlining steps to enable adolescents to gain power and take control of their learning. By involving adolescents as primary participants, this study highlights the significance of the CL method in the school context. Object-oriented power is crucial, as it relates to the meaningfulness of education (Goodman, 2010) and fosters significant learning opportunities that align with students' interests.

This approach empowers students to tackle personal and societal issues, transforming schools into centres of inquiry that enhance engagement (Cook-Sather, 2007; Goodman, 2010) while fostering critical thinking and active citizenship (Vare & Burch, 2024). The notion of object-oriented power, developed through a collective process, emphasises the importance of students driving positive change. Achieving this requires a well-founded interventionist approach (Sannino & Engeström, 2017), commitment from all actors, and a shift in traditional power dynamics driven by student-led initiatives

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ABSTRACT REVIEWED PROCEEDINGS

EMOTIONAL INTELLIGENCE AS A DUAL PATHWAY TO ACADEMIC PERFORMANCE AND HAPPINESS

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ABSTRACT

Emotional Intelligence (EI) has been widely recognized as a key psychosocial competency shaping university students' academic and psychological functioning. However, research has often examined its influence on academic performance and well-being separately, relying on single mediators such as test anxiety or basic psychological needs. The present study proposes an integrated structural model in which EI affects both happiness and academic performance through two parallel pathways. Using data from 205 university students, the analysis incorporated five sequential components: (1) Emotional Intelligence, (2) Cognitive Test Anxiety, (3) autonomy, competence, and relatedness, (4) Happiness, and (5) Academic Performance (GPA). Structural equation modelling (SEM) was used to examine how EI predicts both happiness and academic performance through complementary emotional-cognitive and motivational-affective routes. Results showed that EI negatively predicted CTA and positively predicted autonomy, competence, and relatedness. CTA was a significant negative predictor of GPA, whereas the three needs strongly predicted happiness. EI indirectly influenced academic performance through CTA and indirectly influenced happiness through the basic psychological needs. These findings position EI as a dual-pathway resource that supports academic functioning through the reduction of cognitive test anxiety and enhances students' well-being through the satisfaction of autonomy, competence, and relatedness. Implications for higher education include the importance of fostering emotional skills, supporting basic psychological needs, and creating learning environments that minimize evaluative stress.

INTRODUCTION

University students are required to manage increasing academic demands while simultaneously maintaining psychological well-being and motivation (Bakker & Mostert, 2024). In contemporary higher education contexts characterized by evaluative pressure, performance-based assessment, and emotional challenges, identifying personal resources (e.g., Jagodics & Szabó, 2023) that support both academic performance and subjective happiness has become a central research priority. Among such resources, Emotional Intelligence (EI) has emerged as a critical factor underlying students' capacity to regulate emotions, cope with stress, and function effectively in demanding academic environments (Thomas & Zolkoski, 2020).

EI refers to the ability to perceive, understand, regulate, and utilize emotions in adaptive ways (Mayer et al., 2000). Extensive evidence indicates that emotionally intelligent individuals demonstrate greater emotional regulation, resilience, and adaptive coping, all of which are essential for academic functioning (MacCann et al., 2020). Importantly, EI has been linked not only to performance-related outcomes but also to indicators of psychological well-being (e.g., Shengyao et al., 2024; Vasiou et al., 2024; Vasiou et al., 2025), suggesting that it may operate through multiple pathways rather than a single direct effect.

One key mechanism through which EI may influence academic outcomes is Cognitive Test Anxiety (CTA). CTA is characterized by excessive worry, intrusive thoughts, and cognitive interference during evaluative situations, which impair concentration, working memory, and problem-solving (Thomas et al., 2017). High levels of CTA have consistently been associated with lower academic performance through the activation of cognitive interference mechanisms (Mavrogianni et al., 2025). Students with higher EI are theoretically better equipped to regulate anxiety-related cognition and emotional responses (Geraci et al., 2024), suggesting a negative association between EI and CTA and positioning CTA as a potential mediator between EI and academic performance.

Beyond emotional–cognitive processes, motivational factors play a crucial role in shaping students' academic and psychological functioning. Self-Determination Theory (SDT; Deci & Ryan, 2000) provides a well-established framework for understanding how motivation and well-being are supported through the satisfaction of three basic psychological needs: autonomy, competence, and relatedness. When these needs are satisfied, students are more likely to experience engagement, vitality, and well-being, whereas unmet needs are associated with distress, disengagement, and reduced functioning (Reed-Fitzke & Lucier-Greer, 2021).

Emerging research (e.g., Chen & Zhang, 2022) suggests that emotionally intelligent individuals may be more capable of navigating academic and social environments in ways that promote need satisfaction. For example, emotional awareness and regulation may enhance feelings of competence, facilitate autonomous engagement with academic tasks, and support positive interpersonal relationships, thereby strengthening relatedness. In turn, satisfaction of these basic psychological needs is

a robust predictor of subjective happiness (Tian et al., 2016) understood within positive psychology as a cognitive–affective evaluation of life characterized by positive affect and psychological flourishing.

Although prior research has independently documented associations among EI, CTA, psychological need satisfaction, happiness, and academic performance, these constructs have rarely been examined simultaneously within a unified framework. As a result, it remains insufficiently understood whether EI functions as a dual pathway that concurrently attenuates maladaptive cognitive processes and enhances motivational resources, and how these parallel mechanisms jointly contribute to both academic performance and happiness. Addressing this gap, the present study adopts an integrative structural approach to clarify the interconnected emotional, cognitive, motivational, and affective processes underlying university students' academic success and well-being.

Drawing on EI theory and SDT, the present study proposes a dual-pathway structural model explaining how EI contributes to both academic performance and happiness through two interrelated mechanisms. The first pathway represents an emotional–cognitive route, in which EI is expected to reduce cognitive test anxiety, thereby enabling better academic performance (GPA). The second pathway reflects a motivational–affective route, whereby EI is proposed to enhance the satisfaction of autonomy, competence, and relatedness, leading to higher levels of subjective happiness.

Based on this conceptual model, the study examined the following hypotheses:

H1. EI will be negatively associated with CTA.
H2. CTA will negatively predict academic performance (GPA) and will function as a mediator in the relationship between EI and academic performance.
H3. EI will positively predict autonomy, competence, and relatedness.
H4. Autonomy, competence, and relatedness will each positively predict subjective happiness.
H5. Happiness will be positively associated with academic performance (GPA).
H6. EI will indirectly predict happiness through autonomy, competence, and relatedness.
H7. The integrated structural model will explain meaningful variance in both subjective happiness and academic performance.

METHODS

Participants and Procedure

The sample consisted of 205 university students from the University of Crete, aged 18 to 51 years (M = 23.35), with 86% identifying as female, and enrolled in disciplines within education and the humanities. Data sourcing, ethical approval, and sampling procedures were conducted in accordance with the protocols of the two original studies during the 2022–2023 academic year.

Measures

Emotional Intelligence

Emotional intelligence was measured with the Greek adaptation of the Wong and Law Emotional Intelligence Scale (WLEIS; Kafetsios et al., 2011; Kafetsios & Zampetakis, 2008). The instrument comprises 16 items on a 5-point Likert scale (1 = totally disagree, 5 = totally agree) and reflects Mayer and Salovey's (2000) four EI components: Self-Emotion Appraisal (SEA; e.g., "I always know whether or not I am happy"), Appraisal of Others' Emotion (AOE; e.g., "I am sensitive to the feelings of others"), Use of Emotion (UOE; e.g., "I always tell myself I am competent"), and Regulation of Emotion (ROE; e.g., "I am capable of controlling my emotions"). Reliability was satisfactory ($\alpha = 0.86$, $\omega = 0.87$), with subscale values ranging from $\alpha = 0.68–0.79$ and $\omega = 0.72–0.82$.

Cognitive Test Anxiety

Cognitive test anxiety was evaluated using the Cognitive Test Anxiety Scale–Revised (CTAR; Cassady et al., 2020), a 25-item refinement of the original CTAS Cassady & Johnson, 2002) designed to remove problematic reverse-coded items (Thomas et al., 2017). Items (e.g., "I worry more about doing well on tests than I should") are rated on a 4-point scale (1 = not at all like me, 4 = very much like me). In this study, CTAR showed excellent reliability ($\alpha = 0.95$, $\omega = 0.95$).

Basic Psychological Needs Satisfaction

Basic Psychological Needs Satisfaction (BPNS) was measured using the 21-item scale grounded in SDT (Deci & Ryan, 2000). The scale assesses autonomy (e.g., "I am free to express my ideas and opinions"; seven items), competence (e.g., "Most days I feel a sense of accomplishment from my schoolwork"; six items), and relatedness (e.g., "I really like the people I go to school with"; eight items). Responses were given on a 7-point scale (1 = not true at all, 7 = very true). Each dimension showed adequate reliability (autonomy, competence, relatedness), with overall consistency at $\alpha = 0.87$ and $\omega = 0.88$; subscales ranged from 0.70 to 0.79.

Happiness

Students' happiness was assessed using the Oxford Happiness Questionnaire (OHQ; Hills & Argyle, 2002), with validated Greek versions (Grigoriadou et al., 2024). The OHQ includes 8 items (e.g., "I feel that life is very rewarding") rated on a 5-point scale (1 = strongly disagree, 5 = strongly agree) and has a unidimensional structure [45]. In this study, the scale demonstrated good reliability ($\alpha = 0.74$, $\omega = 0.74$).

GPA

Students' GPA was retrieved from institutional academic records and matched with their questionnaire responses after receiving consent.

Data Analysis

Data analysis was conducted using Jamovi (version 2.6.44). Initial screening included descriptive statistics and Pearson correlation coefficients among all study variables. Prior to model estimation, assumptions relevant to multivariate analyses were assessed, including the presence of missing values, normality of key variables, and potential multicollinearity. No correlation exceeded the range generally considered problematic for structural equation modeling.

Structural equation modeling (SEM) was used to evaluate the dual-pathway conceptual framework. The model included two parallel mechanisms: a) an emotional-cognitive route (EI ⇒ CTA ⇒ GPA) and a motivational-affective route (EI ⇒ autonomy, competence, and relatedness ⇒ happiness). SEM analyses were performed using the Structural Equation Modeling (syntax) module in Jamovi, applying Maximum Likelihood (ML) as the estimation method and NLMINB as the optimization algorithm. Standard fit indices were examined, including χ^2, CFI, TLI, RMSEA with its 90% confidence interval, and SRMR. Both standardized and unstandardized coefficients were obtained.

Indirect effects were estimated through model-defined parameters, and confidence intervals for indirect paths were computed using ML-based standard errors. All tests were two-tailed.

Ethical Considerations

Emotional intelligence had a mean score of 5.13 (SD = 0.71). Autonomy showed a mean of 4.87 (SD = 0.96), competence 4.61 (SD = 0.99), and relatedness 5.32 (SD = 0.88). Subjective happiness had a mean score of 4.17 (SD = 0.79), while cognitive test anxiety showed a mean of 2.27 (SD = 0.69). Academic performance had a mean value of 8.00 (SD = 0.74).

Several correlations among the variables were statistically significant. Emotional intelligence was positively associated with autonomy, competence, relatedness, and happiness ($r = .48$ to $.63$, all $p < .001$), and negatively associated with cognitive test anxiety ($r = -.35$, $p < .001$). The three basic psychological needs demonstrated positive intercorrelations and positive associations with happiness, with the strongest correlation observed between competence and happiness ($r = .71$, $p < .001$). Cognitive test anxiety showed negative correlations with all positive psychological variables, most notably with competence ($r = -.51$, $p < .001$), autonomy ($r = -.41$, $p < .001$), and happiness ($r = -.42$, $p < .001$). Academic performance correlated negatively with cognitive test anxiety ($r = -.20$, $p = .004$), whereas its correlations with emotional intelligence, the basic needs, and happiness were small and not statistically significant.

None of the correlations exceeded the .70-.80 range, which is generally considered acceptable for avoiding problematic multicollinearity in structural equation models (Kline, 2016). To evaluate a five-step theoretical framework, a structural equation

model was estimated in which emotional intelligence (EI) predicted cognitive test anxiety (CTA), autonomy, competence, and relatedness; happiness (OHQ) was predicted by the three basic psychological needs; and academic performance (GPA) was predicted by both happiness and cognitive test anxiety. The overall fit indices were $\chi^2(12) = 171.28$, $p < .001$, CFI = .70, TLI = .48, RMSEA = .26, 90% CI [.23, .30], and SRMR = .14. The model accounted for 12% of the variance in CTA, 23% in autonomy, 34% in competence, 22% in relatedness, 52% in happiness (OHQ), and 5% in academic performance (GPA).

Regarding the structural paths, EI showed a negative association with CTA (β = -.34, $p < .001$) and positive associations with the three basic psychological needs: autonomy (β = .48, $p < .001$), competence (β = .58, $p < .001$), and relatedness (β = .47, $p < .001$). Happiness was positively associated with autonomy (β = .28, p = .002), competence (β = .52, $p < .001$), and relatedness (β = .16, p = .002). Academic performance was negatively related to cognitive test anxiety (β = -.22, p = .002), whereas the path from happiness to GPA was not statistically significant (β = -.03, p = .627). Unstandardized coefficients, standard errors, 95% confidence intervals, and standardized coefficients for all structural paths are presented in Table 1.

Table 1. *Unstandardized and Standardized Parameter Estimates for the Structural Paths of the Five-Step SEM Model*

Dep	Pred	Estimate	SE	95% CI		β	z	p
				LL	UL			
CTA	EI	-0.32	0.06	-0.45	-0.2	-0.34	-5.1	<.001
AUTO	EI	0.62	0.08	0.46	0.78	0.48	7.51	<.001
COMP	EI	0.79	0.08	0.63	0.95	0.58	9.87	<.001
RELAT	EI	0.56	0.08	0.42	0.71	0.47	7.48	<.001
OHQ	AUTO	0.21	0.04	0.13	0.29	0.28	5.25	<.001
OHQ	COMP	0.39	0.04	0.31	0.46	0.52	9.74	<.001
OHQ	RELAT	0.14	0.04	0.05	0.23	0.16	3.11	.002
GPA	OHQ	-0.04	0.07	-0.18	0.11	-0.03	-0.49	.627
GPA	CTA	-0.24	0.08	-0.4	-0.09	-0.22	-3.07	.002

The indirect effects specified in the model were also examined. The indirect path from EI to GPA through CTA was statistically significant (Estimate = 0.11, SE = 0.04, 95% CI [0.03, 0.18], β = .08, p = .009). The indirect effects involving the three psychological needs and happiness in predicting GPA were not statistically significant ($p \geq .62$). These indirect effects included in Table 2.

Table 2. *Indirect Effects Estimated in the Structural Equation Model*

Path	Description	Paramet.	Est.	SE	95% CI		β	z	*p*
					LL	UL			
IE1	EI ⇒ CTA ⇒ GPA	p1*p9	0.08	0.03	0.02	0.14	0.08	2.63	.009
IE2	EI ⇒ AUTO ⇒ OHQ ⇒ GPA	p2*p5*p8	0	0.01	-0.02	0.01	0	-0.48	.629
IE3	EI ⇒ COMP ⇒ OHQ ⇒ GPA	p3*p6*p8	-0.01	0.02	-0.05	0.03	-0.01	-0.49	.628
IE4	EI ⇒ RELAT ⇒ OHQ ⇒ GPA	p4*p7*p8	0	0.01	-0.01	0.01	0	-0.48	.632
IE5	AUTO ⇒ OHQ ⇒ GPA	p5*p8	-0.01	0.02	-0.04	0.02	-0.01	-0.48	.628
IE6	COMP ⇒ OHQ ⇒ GPA	p6*p8	-0.01	0.03	-0.07	0.04	-0.02	-0.49	.627
IE7	RELAT ⇒ OHQ ⇒ GPA	p7*p8	0	0.01	-0.03	0.02	-0.01	-0.48	.631

A graphical representation of the estimated structural model, including all standardized path coefficients, is presented in Figure 1.

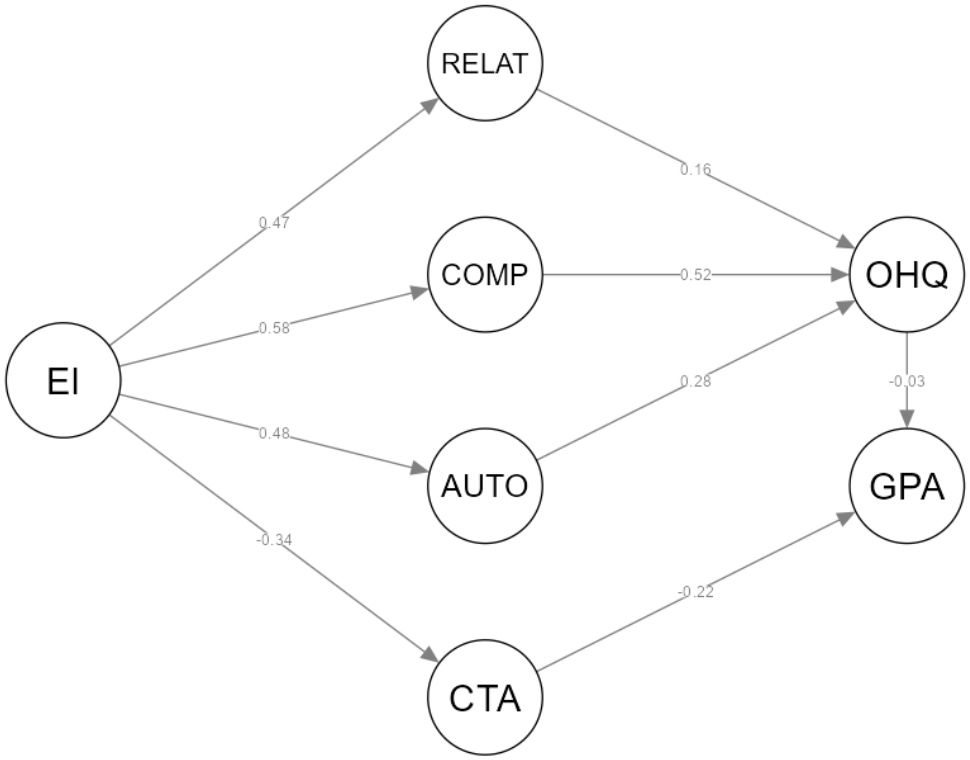

Figure 1. *Dual-pathway Structural Model Linking EI, Psychological Needs, Happiness, and Academic Performance*

DISCUSSION

Overall, the findings support the presence of two distinct yet complementary pathways through which EI shapes university students' functioning. The emotional–cognitive pathway explains academic performance via the reduction of CTA, while the motivational–affective pathway explains subjective happiness through the satisfaction of autonomy, competence, and relatedness. These results provide empirical support for the dual-pathway model, illustrating how emotional, cognitive, and motivational processes jointly influence academic and psychological outcomes. However, the model showed stronger explanatory power for subjective happiness than for GPA, suggesting that academic performance is influenced by additional factors beyond the psychosocial mechanisms examined in this study.

Consistent with H1, higher EI was associated with lower levels of CTA. This supports the view that students with well-developed emotional skills are better equipped to recognize and regulate anxiety-inducing thoughts and emotions that can disrupt cognitive performance. The result aligns with prior research showing that EI facilitates adaptive coping strategies and emotion regulation (Extremera et al., 2020), which in turn reduces test-related worry and intrusive thinking (Zeidner et al., 2021; MacCann et al., 2020). The findings suggest that interventions aimed at enhancing EI (e.g., Elmi, 2020; Moreno-Gómez et al., 2023) may be particularly effective in helping students manage exam-related stress and maintain focus, highlighting the practical relevance of emotional skills training in higher education.
Regarding H2, CTA negatively predicted academic performance and mediated the relationship between EI and GPA. This underscores the pivotal role of cognitive interference in academic outcomes: students who experience high levels of test anxiety may struggle with concentration, working memory, and problem-solving during examinations, even if they possess strong knowledge and skills (Thomas et al., 2017). By mitigating CTA, EI indirectly supports academic performance. These findings resonate with cognitive–motivational models of anxiety (Eysenck et al., 2007), suggesting that emotional regulation contributes to performance by reducing cognitive load and attentional disruption. Practically, this emphasizes the importance of addressing both emotional and cognitive dimensions of student anxiety to optimize learning and performance.

Confirming H3, EI positively predicted autonomy, competence, and relatedness. This indicates that emotionally intelligent students are more likely to feel in control of their academic choices, confident in their abilities, and socially connected within the university environment. These results suggest that developing EI may not only benefit academic outcomes but also enhance students' motivational and relational experiences, fostering a more holistic form of engagement (Zhoc et al., 2020).

As far as H4, autonomy, competence, and relatedness each positively predicted subjective happiness, with competence exhibiting the strongest effect. This finding aligns with extensive evidence from positive psychology and SDT research showing that fulfillment of core psychological needs is a central determinant of well-being (Deci & Ryan, 2000). Competence may have exerted the strongest effect because students' perceptions of effectiveness in their academic tasks directly influence their

sense of accomplishment and emotional satisfaction. The results underscore that happiness in university students is not merely a function of external outcomes but is closely tied to internal experiences of agency, skill mastery, and meaningful social connections (e.g., Nishimura & Joshi, 2021).

Contrary to some expectations (H5), happiness was not directly associated with academic performance, indicating that positive affect alone does not necessarily translate into higher grades. This finding suggests that while well-being is crucial for overall psychological health, academic performance remains largely contingent on cognitive and emotional regulatory processes, such as attention, study strategies, and anxiety management. This resonates with prior research indicating that happiness and positive affect can enhance engagement and persistence but do not always have a direct impact on exam scores (Jerrim, 2022). Practically, this highlights that interventions targeting well-being should complement, rather than replace, strategies designed to optimize cognitive performance.

Consistent with H6, EI indirectly influenced happiness through autonomy, competence, and relatedness, confirming the motivational–affective pathway. This underscores the importance of considering EI not only as a cognitive–emotional resource but also as a facilitator of need satisfaction, which is a key determinant of subjective well-being. The findings suggest that emotionally intelligent students are more adept at navigating academic and social environments in ways that foster autonomy, build confidence, and enhance social bonds, all of which collectively enhance happiness. These results extend prior research on the indirect role of EI in promoting well-being (e.g., Shengyao et al., 2024) and emphasize the potential of integrated interventions that target both emotional skills and need-supportive learning environments.

The dual-pathway model (H7) accounted for substantial variance in subjective happiness but a smaller proportion of variance in academic performance. This suggest that the motivational–affective pathway is particularly influential for psychological well-being, whereas academic performance is a multifactorial outcome influenced by cognitive, motivational, environmental, and emotional factors. While EI contributes indirectly to performance via reduced CTA, other elements such as study strategies (e.g., Hassanbeigi et al., 2011) and institutional context (e.g., Salehi et al., 2021) likely play significant roles. This finding highlights the value of integrated models that consider multiple determinants of student functioning while recognizing the limits of psychosocial predictors for academic outcomes.

LIMITATIONS AND FUTURE DIRECTIONS

Several methodological limitations should be considered. The study relied on a single-institution sample, which restricts the generalizability of the findings to other universities or educational systems. Moreover, the sample was predominantly female, potentially limiting the applicability of the results to more gender-balanced student populations. Finally, the cross-sectional design precludes causal inferences regarding the directionality of the observed relationships. Future research would

benefit from employing longitudinal designs to examine the temporal dynamics and causal ordering of emotional intelligence, test anxiety, psychological need satisfaction, happiness, and academic performance. Additionally, multi-campus and cross-cultural studies are needed to test the robustness and generalizability of the proposed dual-pathway model across diverse educational and cultural contexts. Expanding the model to include additional academic and contextual variables may also enhance its explanatory power, particularly with respect to academic performance.

CONCLUSIONS

The present study provides empirical support for a dual-pathway model illustrating how emotional intelligence contributes to both academic performance and subjective happiness in university students. The findings indicate that emotional intelligence influences academic performance primarily through an emotional–cognitive pathway involving the reduction of cognitive test anxiety, while happiness is shaped through a motivational–affective pathway grounded in the satisfaction of autonomy, competence, and relatedness. By integrating emotional, cognitive, motivational, and affective processes within a single framework, the study advances understanding of student functioning in higher education and underscores the central role of EI as a foundational psychological resource for both performance-related and well-being-related outcomes.

From an applied perspective, the findings suggest that universities should implement comprehensive, theory-driven interventions that simultaneously target emotional regulation and motivational support. Programs aimed at enhancing EI may help students manage evaluative stress more effectively, while structured stress-management initiatives and alternative assessment practices can reduce CTA. At the same time, learning environments that promote autonomy, competence, and relatedness, through meaningful choice, mastery-oriented feedback, and collaborative experiences, are likely to foster student happiness and psychological well-being. By adopting the dual-pathway model as a guiding framework, higher education institutions can design integrated strategies that address both academic demands and student well-being in a coordinated and sustainable manner.

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PRIMARY SCHOOL-AGED CHILDREN'S EXPERIENCES, VIEWS, AND VISIONS OF AI: A MIXED-METHODS STUDY

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ABSTRACT

This mixed-methods study examines how primary school-aged children (PSCs) perceive, experience, and envision artificial intelligence (AI) in their current lives and imagined futures. It explores how children conceptualise AI, how they understand its benefits and risks, and how these views relate to their everyday interactions with AI-enabled technologies at home, in school, and in leisure contexts. Particular attention is given to how socio-economic and cultural contexts shape access, familiarity, trust, and levels of concern, recognising that children's encounters with AI vary widely across households, schools, and communities. The research combines a child-friendly online survey (approximately 100 PSC aged 7-11) with focus groups involving children aged 5-11, using creative draw-and-tell activities to capture both breadth and depth in children's perspectives. Data collection methods were tailored by age, with a child-friendly survey administered to children aged 7–11 years and focus groups involving children aged 5–11 years, using age-appropriate, task-based activities to support the participation of younger children (particularly those aged 5–6 years). Descriptive and inferential statistics illuminate trends and group differences, while thematic analysis uncovers recurring themes in children's narratives and imaginative accounts of AI. By foregrounding PSC voices, the study aims to inform child-centred AI education, ethical AI development, and policy responses that reflect and respect children's needs, values, and rights.

INTRODUCTION

Artificial intelligence is increasingly integrated into children's everyday environments, encompassing education, entertainment, communication, healthcare, and consumer technologies. Primary school-aged children may encounter AI through voice assistants, recommendation systems, educational platforms, digital games, social robots, and automated content filters, often without explicit awareness that AI powers these technologies. This early and essentially ubiquitous exposure

raises important questions about how children understand AI, how they feel about it, and how they imagine its role in their futures (Heeg & Avraamidou, 2025).

Despite this growing presence, much empirical work on AI focuses on adults, experts, or older students, leaving the perspectives of younger children underexplored. PSCs are not passive users of technology; they interpret systems, attribute meaning to them, and integrate these systems into their social worlds, drawing on developmental, social, and cultural resources (Kumpulainen et al., 2020). Early encounters with AI may influence attitudes towards technology, notions of intelligence and agency, and expectations about work and learning in later life. At the same time, public and policy debates about AI in education often emphasise efficiency, performance, and innovation over children's lived experiences and rights (Charisi et al., 2022).

International initiatives emphasise that AI must be aligned with the UN Convention on the Rights of the Child, including rights to participation, protection, and provision in digital environments (UNICEF Innocenti, 2025). AI systems can shape children's access to information, opportunities for learning, and the forms of monitoring and assessment they experience at school. Ensuring that AI supports, rather than undermines, children's rights requires direct engagement with children's perspectives and a nuanced understanding of how they make sense of AI in context (Chaudron & Di Gioia, 2022).

This study foregrounds the experiences, views, and visions of PSCs regarding AI. It investigates how children conceptualise AI, how they perceive its current role in their lives, and how they imagine its future impact on education, work, and society. It also examines how socio-economic and cultural contexts influence access to AI technologies, familiarity, trust, and concerns. By centring children's voices, the research aims to contribute to inclusive AI literacy initiatives, ethically informed educational practices, and child-centred policy development that acknowledge both opportunities and risks associated with AI.

LITERATURE REVIEW

Research highlights both opportunities and risks of AI in education. AI can support personalised learning, automate administrative tasks, and improve access to resources. However, much of this work reflects educator or adult perspectives, focusing on issues such as effectiveness, scalability, and data-driven decision-making (Vieriu & Petrea, 2025). AI systems such as adaptive learning platforms, intelligent tutoring systems, and automated marking tools are often presented as neutral innovations, despite growing recognition that they embed particular values, assumptions, and power relations. These systems can change how learning is organised, how pupils are evaluated, and how teachers allocate their time and attention.

A systematic review indicates that children's understandings of AI are shaped by media, parental guidance, and classroom experiences, with limited in-depth analysis across diverse PSC populations (Lee & Kwon, 2024). Children's conceptions of AI

are frequently informed by popular culture and fictional representations, which can emphasise superhuman abilities, autonomy, and threat. Such representations can lead to anthropomorphic or overly simplistic conceptions of AI, where systems are imagined as human-like agents that think, feel, or intend harm or help. These imaginative accounts reveal creativity and engagement, but also highlight gaps in technical literacy and challenges for AI education.

Children often exhibit excitement alongside ethical concerns such as privacy, surveillance, and job displacement, and socio-economic and cultural contexts significantly influence trust and expectations (UNICEF Innocenti, 2021). Children from households with higher levels of access to digital technologies may encounter AI as a helpful, everyday tool. In contrast, those with more limited access may encounter it primarily through media narratives or institutional settings, such as schools and educational institutions. Research also highlights how parental attitudes, school policies, and broader cultural discourses about innovation and risk shape children's willingness to trust AI systems and their views on where and how AI should be used.

Existing studies point to several key tensions: the promise of AI to support personalised learning versus concerns about datafication and surveillance; narratives of neutrality and objectivity versus evidence of bias and exclusion; and aspirations for enhanced participation versus the marginalisation of children's voices in design and governance. Children's understandings frequently feature anthropomorphic or overly simplistic conceptions of AI, revealing imaginative engagement but also gaps in technical literacy. The literature emphasises the need for child-centred research that goes beyond measuring attitudes to explore how children narrate, visualise, and emotionally respond to AI. Such research can inform inclusive AI education, ethically informed technology design, and policy frameworks that recognise children as active social performers rather than passive users (Alfredo et al., 2024).

AI in Education: Potential and Controversy

Research on AI in education highlights both the opportunities and risks associated with it. AI-driven systems, such as adaptive learning platforms, intelligent tutoring, and automated assessment, are claimed to support personalised learning, reduce teacher workload, and improve access to resources (Holmes et al., 2019; Luckin & Holmes, 2016; Zhai et al., 2021). These tools can provide real-time feedback, identify misconceptions, and tailor learning pathways, aligning with policy agendas that promote data-informed teaching and "future-ready" skills.

However, critical scholars emphasise that AI systems are not neutral; they embed particular pedagogical models, assumptions, and power relations (Biesta, 2020; Knox, 2020; Selwyn, 2019). Data-driven platforms can intensify surveillance, narrow curricular focus, and shift decision-making power from teachers to opaque algorithms. Evidence from exam grading algorithms and learning analytics suggests that AI can reproduce or exacerbate inequalities, particularly for socioeconomically disadvantaged and minority learners, if fairness and transparency are not prioritised.

Children's Understandings and Perceptions of AI

A growing body of work focuses explicitly on children's understandings of AI. Children's concepts of AI are shaped by direct interactions with technology, media portrayals, and explanations from adults, especially parents and teachers (Druga et al., 2017; Lee & Kwon, 2024). Studies consistently report anthropomorphism: children often attribute emotions, intentions, or moral agency to AI devices such as smart speakers and social robots (Andries & Robertson, 2023; Kory-Westlund & Breazeal, 2019). These attributions can increase engagement and motivation but also indicate misconceptions about the computational nature of AI and its limitations (Deshpande et al., 2023; Scorici et al., 2022).

Intervention studies suggest that AI education can enhance functional understanding while preserving some anthropomorphic tendencies. For example, in the PopBots activities introduced, preschool children engaged in hands-on activities such as training simple machine-learning models by sorting images and observing how robots used data to make decisions (simplified, play-based activities illustrating concepts). The children demonstrated conceptual gains, i.e., the activity supported their understanding of supervised learning and data-driven systems; however, many still described robots as "smarter than me" or "like a person". Overall, supporting making AI concepts accessible is highly important (Park, 2019; Williams et al., 2019). Similarly, primary pupils in Sweden developed more nuanced views of AI after participating in classroom-based AI lessons which addressed how AI systems work, their limitations and their societal implications, but continued to express mixed feelings about its benefits and risks, e.g., excitement about the benefits, concerns about risks like fairness, loss of control, etc. (Walan, 2024).

Socio-Economic, Cultural, and Media Influences

Socio-economic and cultural factors strongly mediate children's perceptions of AI. Access to AI-enabled devices, quality of connectivity, and parental digital literacy all shape how frequently and in what ways children encounter AI (Eynon & Geniets, 2016; Livingstone & Blum-Ross, 2020). Children from affluent households often experience AI as a helpful everyday assistant, while others may know AI primarily through school technologies or fictional media. These differences influence trust, perceived usefulness, and levels of concern.

Media representations also play a decisive role. Science fiction movies and games often depict AI as super-intelligent, sentient, or threatening, which can produce exaggerated hopes or fears among children (DiPaola et al., 2022). More realistic educational media can promote a balanced view of AI as a tool that supports, rather than replaces, human teachers (Chaudhry & Kazim, 2021). Without critical media literacy, children may oscillate between over-reliance on AI and rejection of AI-enhanced learning tools.

Children from affluent households often encounter AI through personal assistants, such as smart speakers, which fosters higher trust and perceptions of usefulness for

daily tasks. At the same time, those from less privileged backgrounds primarily experience AI via school technologies or media portrayals, leading to greater scepticism and concerns about reliability and privacy (Latham & Montacute, 2025; Picton & Clark, 2024). These socioeconomic differences shape emotional responses to AI, with privileged children expressing optimism and lower anxiety, compared to heightened worries about control and fairness among others.

Theoretical Perspectives

Developmental theories offer lenses for understanding how children make sense of AI. Piaget's constructivism emphasises active exploration and cognitive conflict as drivers of learning, raising questions about whether AI systems that provide quick answers reduce opportunities for productive struggle and schema change (Piaget, 1952). Vygotsky's sociocultural theory emphasises social interaction and scaffolding; in this view, AI systems can serve as "more knowledgeable others" when they facilitate dialogue, collaboration, and progressive autonomy (Vygotsky, 1978; Matsuda et al., 2014).

Social cognitive theory and identity frameworks also highlight how observing and interacting with AI systems may influence children's self-efficacy, aspirations, and sense of agency (Bandura, 1977; Erikson, 1968). Anthropomorphism and parasocial relationships with AI agents may shape identity formation and social learning in ways that are still poorly understood (Druga et al., 2017; Möri, 2024). These theoretical perspectives underscore the need for empirical studies that consider children's developmental stages and social contexts.

Kurian (2025) frames child-safe conversational AI as a sociotechnical system in which ethical, developmental, and technical considerations intersect. The three key dilemmas of safety versus engagement, personalisation versus privacy, and autonomy versus protection highlight the trade-offs inherent in designing AI for children. From a sociocultural and child-computer interaction perspective, these dilemmas position children as active agents whose learning and exploration are shaped by the design of technology, illustrating how responsible AI must balance usability, learning potential, and ethical safeguards. This provides a conceptual lens for understanding complex child–AI interactions.

Identified Gaps

Overall, existing literature shows that children's understandings of AI are complex, context-dependent, and often internally contradictory. However, PSC, especially those aged 5-11, remain underrepresented in empirical work compared with adolescents and university students. Few studies use mixed-methods designs that combine broad survey data with in-depth, creative qualitative methods to examine how children both describe and imagine AI in their lives.

There is also limited research that explicitly foregrounds children's rights and participation in relation to AI in education. Many discussions about AI and schooling are conducted by adults and for adults, with children's experiences appearing only

as anecdotes or outcome measures. The present study addresses these gaps by centring PSCs' voices, using a mixed-methods design and creative methodologies to explore their experiences, views, and visions of AI across multiple contexts.

RESEARCH QUESTIONS

1. What attitudes and understandings do primary school-aged children have about artificial intelligence in their everyday lives and educational environments?
2. How do socio-economic and cultural backgrounds influence children's experiences, levels of access, and conceptualisations of AI?
3. How do children envision AI shaping their future in education, work, and broader society?
4. How can children's perspectives inform AI-related educational strategies, AI literacy initiatives, and ethical AI development?
5. These questions are designed to connect individual children's accounts with broader debates on AI in education and children's digital rights.

RESEARCH DESIGN AND METHODOLOGY

This study employs a mixed-methods design to capture the breadth and depth of perspectives on AI from PSCs. Combining quantitative and qualitative approaches facilitates a nuanced understanding of how children discuss, envision, and interact with AI in various contexts. Quantitative and qualitative data are collected in parallel and integrated during analysis and interpretation, allowing for the exploration of convergences and divergences between strands. To accommodate developmental differences among participants, data collection methods were tailored by age group. Children aged 7-11 years participate in a survey-based component, as this age range is better suited to structured questionnaires and independent response formats. In contrast, children aged 5–11 years participate in focus groups, which employ age-appropriate, task-based activities to facilitate discussion and expression. This methodological distinction reflects the challenges younger children, particularly those aged 5-6 years, may face when completing surveys, while allowing their perspectives to be meaningfully captured through interactive and facilitated group methods.

Quantitative Component

Approximately 100 PSC aged 7-11 complete a child-friendly online survey with visually adapted Likert-type items. The survey assesses several domains, including awareness of AI, frequency and type of interaction with AI-enabled technologies, curiosity and enjoyment, perceived usefulness, trust, and ethical concerns such as privacy and fairness. To make items accessible, response scales use simple wording and visual supports (for example, smiley faces) that have been found effective in work with children (Hall, Hume, & Tazzyman, 2016). The survey invites children to share their views on AI by providing prompts that include examples they may be familiar with from their daily lives.

Participants are recruited through schools, community organisations, newsletters, and snowball sampling to ensure socio-economic and cultural diversity (Salem et al., 2023). Efforts are made to involve schools serving different catchment areas, including those with varying levels of deprivation and linguistic diversity, to explore how contextual factors shape experiences. Demographic information, including age, school year, gender, language background, and socioeconomic status indicators, is collected to facilitate comparisons across groups.

Data are analysed using descriptive and inferential statistics (for example, SPSS) to examine patterns across age, gender, and background. Descriptive statistics summarise patterns of AI use, perceived benefits, and levels of concern, while inferential techniques are used to investigate group differences and relationships between variables. For instance, analyses may explore whether older children report higher AI awareness than younger children, or whether children from different socio-economic contexts differ in their levels of trust or perceived risk.

Qualitative Component

Focus groups are conducted within participating schools with four to eight children per group, aged 5-11. Group composition is carefully considered to support comfortable participation, taking into account age range, peer relationships, and language needs. Sessions begin with warm-up activities designed to build rapport and establish ground rules, focusing on respect, turn-taking, and confidentiality, using age-appropriate language and examples.

Creative draw-and-tell activities complement verbal discussion, enabling expression beyond words and supporting inclusive participation (Goodwin, Savage, & O'Donovan, 2023). Children are invited to draw how they imagine AI now and in the future, including its role in school, at home, and in society. They then explain their drawings to the group, providing narratives that reveal how they make sense of AI and what they expect from it. This approach aligns with child-centred research practices and ethical engagement with children's imaginative and future-oriented ideas (Adler, Salanterä, & Zumstein-Shaha, 2019). It is particularly valuable for younger participants and those who may find abstract or technical questions difficult to understand.

Focus groups are audio-recorded, and where possible, children's drawings are photographed or scanned with their consent. Field notes capture non-verbal cues, group dynamics, and contextual factors that may influence discussion. This multimodal dataset enables the exploration of both explicit statements and more implicit meanings conveyed through imagery, metaphor, and shared storytelling.

DATA ANALYSIS

Qualitative data are analysed using thematic analysis following a six-stage process: familiarisation, coding, theme development, refinement, exemplar selection, and analytic narrative (Clarke & Braun, 2017; Kisovar-Ivanda, 2014). Transcripts from focus groups, together with notes and images of children's drawings, are read

repeatedly to gain an overall sense of their narratives and representations. Initial coding is conducted inductively, capturing both semantic content and more interpretative insights, such as underlying assumptions about agency, intelligence, and control.

Codes are then reviewed and clustered into potential themes, for example, “AI as helper”, “AI as threat”, “AI as friend”, “surveillance and privacy”, or “imagined AI futures in school”. Themes are refined through iterative comparison across age groups and contexts, ensuring that they are coherent, distinct, and grounded in the data. Exemplar quotes and images are selected to illustrate each theme, with care taken to preserve children’s voices and avoid sensationalising their concerns or fantasies. Where appropriate, a more deductive lens is used to connect emergent themes with concepts from the literature, such as anthropomorphism, datafication, or children’s rights.

Quantitative data are analysed descriptively and inferentially to identify overall patterns and differences across groups. Descriptive statistics summarise central tendencies and distributions for key variables, while inferential analyses (for example, correlations, comparisons between age groups or socio-economic categories) examine relationships and group differences. The aim is not to generalise to all children but to explore meaningful patterns that complement and inform the qualitative findings. Triangulation of qualitative and quantitative findings enhances credibility and robustness of the study (Creswell & Plano Clark, 2007). Points of convergence and divergence between survey results and focus group narratives are examined to develop a richer, more integrated account of PSC experiences, views, and visions of AI.

FINDINGS

Preliminary findings reveal a diverse range of perspectives on PSC. Many children express enthusiasm about AI’s potential to support learning, answer questions quickly, and assist with daily tasks. AI is often described in favourable terms such as helpful, clever, or engaging, particularly when connected to familiar technologies like voice assistants, search tools, and educational games. Children frequently highlight convenience and speed, describing AI as something that makes life easier or more fun.

At the same time, ethical concerns about privacy, surveillance, and potential displacement of human roles appear. Some children worry about AI “watching” them or collecting information without their knowledge, while others express fears that AI might take over jobs or “control everything”. Misconceptions, including attributing emotions, intentions, or moral agency to AI, are evident and indicate gaps in AI literacy. For instance, AI is sometimes described as a friend that can feel sad or lonely, or as a powerful being that might decide to harm people.

There are apparent variations across socio-economic and cultural contexts, influencing familiarity with AI technologies, levels of trust, and expectations for future use. Children with more frequent access to digital devices and online

platforms tend to provide more concrete examples of AI in their daily lives. In contrast, those with more limited access sometimes draw on media narratives or science fiction when imagining AI. Differences also emerge in the extent to which AI is viewed as a tool that can support school success, a source of risk, or something distant and abstract. These patterns underline the importance of context-sensitive AI education that acknowledges diverse experiences and starting points.

IMPLICATIONS FOR EDUCATIONAL PRACTICE

Results support the introduction of AI education at an early age, using developmentally appropriate and culturally responsive approaches. Classroom activities could include guided discussions about the presence of AI in children's lives, hands-on exploration of simple AI-driven tools, and inquiry-based projects where children investigate questions related to fairness, privacy, and reliability. Such activities can help move beyond purely technical or instrumental framings to address ethical and societal dimensions of AI.

Curriculum should address both opportunities and ethical challenges, fostering critical engagement rather than passive acceptance or fear. Teachers need support and professional development to feel confident in facilitating conversations about AI, particularly when children raise complex questions or concerns. Children's perspectives can inform the design of child-centred AI tools that prioritise privacy, transparency, and meaningful learning support. Involving children as stakeholders in AI-related decision-making, such as through consultation on digital policies or participation in co-design activities, can help ensure that educational technologies reflect their needs, values, and rights.

ETHICAL CONSIDERATIONS

The study adheres to the ethical guidelines applicable to research involving children. Informed consent is obtained from parents or guardians, with child assent obtained as appropriate. Participants are informed that they may withdraw at any time without incurring any negative consequences, and their data are anonymised and securely stored.

Child-friendly language and creative methods support meaningful participation, helping to mitigate potential harm. Particular care is taken in interpreting and presenting children's creative outputs to ensure respectful and ethical representation (British Psychological Society, 2021).

LIMITATIONS

The study acknowledges several limitations. The geographically limited sample may affect the generalisability of findings, particularly with respect to national or international diversity. Self-reported data may be influenced by social desirability biases and by partial understandings of AI concepts, meaning that children's accounts may mix direct experience with hearsay or fictional narratives. In addition,

the cross-sectional design does not capture how children's perceptions of AI evolve over time or in response to specific educational interventions.

Although socio-economic and cultural diversity is considered through recruitment strategies, broader national or cross-country comparisons can fall outside the scope of this study. The study also focuses on children who can participate in group discussions and online surveys, which may underrepresent children with particular communication or access needs. Future research could extend the sample to additional regions and contexts, adopt longitudinal or participatory designs, and explore in more depth how AI education initiatives influence children's understandings, feelings, and behaviours over time.

CONCLUSION

This child-centred mixed-methods study provides timely insights into perceptions and imaginings of PSCs regarding AI. By combining quantitative survey data with creative qualitative methods, the research aims to offer nuanced insights into children's hopes, concerns, and misconceptions. The findings can inform inclusive AI education, ethical technology development, and policies that more effectively incorporate children's voices.

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SHAPING TOMORROW'S SCHOOLS: DESIGNING SOCIAL VR TRAINING FOR FUTURE COMMUNICATION SITUATIONS

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ABSTRACT

Digital transformation is fundamentally changing the way people communicate and is therefore also reshaping communication practices in schools. Unlike traditional digital tools, social virtual reality (SVR) enables synchronous, immersive interaction and thus offers new possibilities for professional communication. This practice-based article presents the development of a teacher training concept that has been tested iteratively as part of a design-based research (DBR) approach. The aim is to show teachers the potential of SVR for school communication processes and to promote their socio-communicative skills in virtual environments.

INTRODUCTION: TECHNICAL POTENTIALS OF SOCIAL VIRTUAL REALITY FOR SCHOOLS

Over the past decade, the use of digital communication technologies has increased, particularly in organisational and administrative settings. Video conferencing systems, collaborative platforms and messaging tools are now well established in everyday practice. However, despite their widespread use, these tools often remain limited with regard to social presence, embodied interaction and therefore the quality of collaborative communication (Mulaimovic et al., 2024).

Social Virtual Reality (SVR) offers a technologically development within the landscape of digital communication tools. SVR enables synchronous, multi-user interaction in immersive three-dimensional environments, where users are represented by avatars and interact through speech, gestures and spatial positioning (Maloney & Freeman, 2020). In contrast to two-dimensional video conferencing, SVR allows users to experience a strong sense of "being there together", commonly described as co-presence (Cummings & Bailenson, 2016; Wei et al., 2025).

Communication in SVR is not limited to verbal exchange (e. g. moderation group discussion, presenting ideas in a SVR-meeting) but is enriched by non-verbal cues such as body orientation, distance, gesture and movement within shared virtual spaces.

From a technical perspective, SVR combines several affordances that are relevant for professional communication. First, VR headsets and controller and embodied interaction enhance users' sense of presence. Second, avatar-based representation enables a transmission of social signals, which can support mutual understanding and trust toward other users. Third, shared virtual environments allow for collaborative activities, such as working with virtual whiteboards, documents or spatial visualisations, in ways that resemble face-to-face interaction more closely than conventional digital tools (Barreda-Ángeles et al., 2023).

For schools, these technological affordances are especially relevant beyond classroom instruction. Professional communication among teachers, school leaders and external stakeholders is an essential component of school development and organisational learning (Dubs, 2019). As schools increasingly operate in hybrid communication environments, SVR may become an additional and independent mode of their professional interaction. Consequently, teachers need opportunities to explore, experience and critically reflect on SVR as a communication medium within structured professional development contexts (Wampfler, 2014).

We would like to explore this issue below and present the results of a design-based research project in the lernen:digital LeadCom network in Germany, in which a training concept for teachers on dealing with and communicating in SVR was developed and evaluated.

THEORETICAL BACKGROUND: COMMUNICATION STRUCTURES IN EVERYDAY SCHOOL PRACTICE

Communication in schools is characterised by complexity, diversity and a multiplicity of actors. Teachers communicate not only with students in instructional contexts but also with colleagues, school leadership and a range of external stakeholders such as parents, training companies or educational authorities (Beil & Gerholz, 2024). These communication processes differ in terms of formality, hierarchy and purpose and are embedded in organisational routines and institutional structures.

Empirical research highlights that face-to-face communication continues to play a dominant role in everyday school practice, particularly for informal exchange and relationship-building. At the same time, digital communication tools have gained importance, especially for formal meetings, coordination tasks and documentation processes. The COVID-19 pandemic acted as a catalyst for this development and accelerated the adoption of digital communication formats in schools (Mulaimovic et al., 2024).
A qualitative interview study with vocational school teachers served as a preliminary study for the present project (Beil & Gerholz, 2024). The findings indicate that

teachers perceive SVR as a potentially valuable environment for selected professional communication settings, particularly collaborative meetings within subject departments or cross-organisational contexts. Compared to video conferencing, SVR was associated with expectations of more natural interaction, improved collaboration and a stronger sense of group cohesion. At the same time, the study revealed limited concrete experience with immersive technologies and considerable uncertainty regarding practical implementation. Teachers expressed a need for orientation, low-threshold experimentation and professional support. These findings underline the relevance of targeted professional development that addresses both communicative practices and technological competencies related to SVR.

METHOD: DESIGN-BASED RESEARCH APPROACH

The development of the professional development programme followed a Design-Based Research (DBR) approach. DBR aims to address complex educational problems through the iterative design, implementation and refinement of interventions in close collaboration between researchers and practitioners (Reinmann, 2005; Gerholz & Wagner, 2022). In addition to improving practical solutions, DBR seeks to generate transferable design knowledge.

In this project, the teacher training itself served as the central design artefact. The initial design was informed by insights from the preliminary study as well as by established principles of effective teacher training (Lipowsky & Rzejak, 2021).

Several guiding design principles shaped the training. First, the training focused on authentic professional communication scenarios (e. g. virtual participation in a departmental conference or simulation of a consultation with a student) rather than instructional use of VR. Second, participants were given opportunities for hands-on exploration of SVR environments in collaborative settings. Third, the programme included differentiated learning stations to accommodate varying levels of prior experience with immersive technologies. Finally, structured reflection phases were integrated to support critical reflection of SVR's potential and limitations for everyday school communication. The teacher training aimed to foster both digital competencies related to SVR technologies and socio-communicative competencies required for professional interaction in immersive environments.

RESULTS: DESIGN CYCLES AND TRAINING CONCEPT

The two conducted design cycles involved the implementation of the teacher training as a short in-service teacher training session at a vocational school. The training combined brief input phases with experiential learning activities in SVR. Participants explored different virtual environments and engaged in collaborative tasks simulating professional communication situations, such as virtual meetings or joint work on shared artefacts. Learning stations enabled differentiation according to participants' prior experience with VR, ranging from exploration to experience to construction (Gerholz et al., 2022).

The evaluation of the first design cycle indicates high acceptance and positive affective responses among participants. Teachers reported enjoyment, curiosity and a strong sense of immersion during the SVR activities. Usability and comprehensibility of the training design were also rated positively. At the same time, participants stated the potential relevance of SVR for everyday school communication. SVR was primarily perceived as suitable for selected scenarios, particularly collaborative meetings, communication with external partners.

These findings suggest that while SVR is experienced as engaging and technically promising, its integration into everyday school communication requires realistic framing and concrete use cases. The results also highlight the importance of addressing teachers' professional perspectives and existing communication routines when introducing immersive technologies through teacher training.

OUTLOOK

The results of the two conducted design cycles suggest that SVR has the potential to enrich professional communication in schools by providing immersive and socially rich interaction spaces. However, SVR should be understood as a complementary communication format rather than a replacement for existing modes. Its successful integration into school practice requires targeted professional development, clear organisational use cases and opportunities for sustained experimentation.

As schools increasingly operate in hybrid environments, SVR is poised to become an essential pillar of professional interaction beyond traditional classroom instruction. The transition from 2D video conferencing to immersive 3D collaboration marks a shift in school communication culture. To ensure that schools remain capable of acting in these new digital spheres, it is crucial to integrate SVR training into standard teacher professional development. By fostering socio-communicative skills in virtual environments today, it can be empowered teachers and school leaders to utilize SVR as an effective medium for collaboration, leadership, and organizational learning in the long term.

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BUILDING PEDAGOGICAL LEARNING ORGANISATIONS IN RWANDA: AN APPLICATION OF SENGE'S FRAMEWORK

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ABSTRACT

Rwanda has positioned itself as one of Africa's most ambitious reformers in digital education, creating pressure for higher education institutions (HEIs) to evolve into adaptive learning organisations capable of responding to technological and pedagogical change. This study applies Senge's (2006) learning organisation model to examine its relevance within the Rwandan higher education context. It investigates whether targeted training in digital pedagogies can support HEIs in developing the characteristics of learning organisations and explores how Senge's core principles can be operationalised in Rwanda.

The research adopts a qualitatively driven mixed-methods design, drawing on data collected from an online questionnaire and observational field notes. Findings indicate that transforming into a learning organisation is a gradual process and requires sustained facilitation and institutional commitment. The training produced the strongest improvements in personal mastery, mental models, and team learning, with more modest gains in shared vision and the weakest progress in systems thinking. These results suggest that future capacity-building initiatives should prioritise institutional-level development to strengthen systemic perspectives. While enhancing educators' digital pedagogical competences is essential, broader institutional transformation is equally critical for sustaining educational quality.

The results align with Rwandan policy priorities articulated in Vision 2050 and the National Strategy for Transformation 2, particularly regarding innovation, accountability, and the development of digitally skilled human capital. This study was conducted within the Higher Education Pedagogies for Teacher Education (HEP TED) project, funded by the Finnish Ministry for Foreign Affairs.

RWANDAN HIGHER EDUCATION IN THE ERA OF DIGITAL TRANSFORMATION

Rwanda has emerged as one of Africa's most ambitious leader in educational reform, leveraging digital transformation as a central strategy for achieving knowledge-based economic growth. The country's policy vision, anchored in *Vision 2050* and the *National Strategy for Transformation 2 (NST2)* (Republic of Rwanda, 2024), recognizes education as the foundation of innovation, productivity, and inclusive development. Within this framework, higher education institutions (HEIs) are expected not only to produce skilled graduates but also serve as catalysts for research, innovation, and social transformation (Nsengimana, 2022; UNESCO, 2023).

Digitalisation has accelerated across tertiary education, driven by governmental priorities, international partnerships, and institutional reforms. The Rwanda Polytechnic (RP) and the University of Rwanda (UR), the country's two largest public HEIs, are central to this shift. Both institutions are mandated to embed digital competencies, adopt blended learning models, and align curricula with labour market needs. Initiatives such as Higher Education Pedagogies for Teacher Education (HEP-TED) project, co-funded by the Finnish Ministry for Foreign Affairs, exemplify collaborative efforts to promote digital pedagogy and foster innovation-oriented teaching.

National Strategy for Transformation 2 (NST2) and Educational Reform

The National Strategy for Transformation 2 (NST2) (2024–2029) represents Rwanda's renewed development roadmap, outlining pathways toward achieving Vision 2050. The strategy emphasises human capital development as a driver of socio-economic progress. Digital transformation is identified as essential for competitiveness and resilience (Republic of Rwanda, 2024). NST2 prioritises digital literacy, innovation ecosystems, and education system reform as drivers of inclusive growth. It emphasises the need to integrate ICT across all education levels, from early learning to higher education, ensuring that digital tools enhance quality, accessibility, and relevance (MINEDUC, 2024). Importantly, the strategy recognises disparities in infrastructure and digital competencies, and calls for targeted investments in connectivity, teacher training, and digital content development (Rwanda Information Society Authority [RISA], 2023).

For HEIs, NST2 presents a dual challenge: aligning academic programmes with labour market demands while cultivating institutional cultures of innovation and accountability (Mukamana & Bizimana, 2022). The University of Rwanda and Rwanda Polytechnic are central to this mission, expected to lead the production of digitally competent graduates and to champion innovation-led teaching. Although RP and UR have made progress, implementation remains uneven due to funding constraints, bureaucratic processes, and fragmented professional development structures (Kamanzi & Musafiri, 2022).

Rwanda's ICT in Education Policy 2016 reinforces NST2's priorities by promoting infrastructure development, teacher capacity-building, and e-learning integration (MINEDUC, 2020). Similarly, the National Digital Talent Policy (2023) provides a framework for aligning higher education curricula with national digital economy objectives (RISA, 2023). Collectively, these policies reflect an ecosystem-level commitment to digital transformation. However, sustaining the shift requires not only technological inputs but also deep pedagogical and cultural change within institutions.

Within this environment, projects like HEP-TED have gained significance. They act as bridges between policy intent and institutional capability by operationalising digital pedagogy training and fostering collaborative curriculum design. As Senge (2006) argues, sustainable organisational change requires learning at all levels, individual, group, and systemic. Rwanda's higher education reform, therefore, must move beyond compliance with policy directives toward cultivating adaptive learning institutions capable of evolving with technological and pedagogical shifts.

Institutional Landscape: University of Rwanda and Rwanda Polytechnic

Rwanda's two largest public HEIs, the University of Rwanda (UR) and Rwanda Polytechnic (RP), play distinct yet complementary roles in the country's education ecosystem. Both are tasked with promoting digital transformation, innovation, and workforce readiness, though their institutional contexts differ substantially.

University of Rwanda (UR)

Established in 2013 through the merger of several public universities, the University of Rwanda is a research-led institution with six constituent colleges, including the College of Education (CoE)—a key participant in the HEP-TED initiative. UR's strategic vision emphasises internationalisation, digitalisation, and research excellence (University of Rwanda, 2023). Initiatives such as the Centre for Open and Distance Learning (CODL) and Learning Management System (LMS) adoption demonstrate progress toward digital integration.

Nevertheless, implementation challenges persist. An internal evaluation (UR, 2022) found that although over 80% of lecturers reported using digital tools such as Moodle and Zoom, only 37% consistently applied them for interactive, learner-centred instruction. The gap between technical proficiency and pedagogical transformation remains significant. Limited time for experimentation and heavy teaching loads, undermine sustained innovation (Mukabatsinda & Niyibizi, 2023). Moreover, digital pedagogy initiatives are often fragmented and project dependent. This reflects what Senge (2006) describes as the absence of *systemic alignment*, where isolated innovations fail to influence organisational culture or strategic vision. UR's efforts, therefore, must focus not only on capacity-building but also on institutionalising reflection, collaboration, and shared learning across departments.

Rwanda Polytechnic (RP)

Rwanda Polytechnic was established in 2017, and it oversees eight colleges distributed across the country. RP's mission aligns with national workforce priorities, particularly in technical and vocational education and training (TVET). The institution seeks to produce graduates with both practical and digital competencies suited to emerging industries (Rwanda Polytechnic, 2023). However, RP's decentralised structure presents unique challenges. Many RP Colleges operate with limited bandwidth, outdated equipment, and constrained access to digital content (Nkurunziza, 2023). Instructors, often recruited from industry, may possess strong technical skills but lack pedagogical training in digital or student-centred methods. Institutional resources for coordinated professional development remain scarce, leading to uneven digital literacy levels across campuses (Higher Education Council, HEC, 2022).

Despite these challenges, RP has shown commitment to digital reform. Initiatives such as the RP E-learning Portal, partnerships with Smart Africa, and digital content production workshops indicate growing institutional engagement. Importantly, RP's participation in HEP-TED project has facilitated cross-institutional collaboration with UR and other HEIs in Finland, promoting shared learning in curriculum design and pedagogical innovation.

Both institutions thus exemplify the tension between policy ambition and institutional reality. Their experiences highlight the need for systemic learning, where individuals and teams continuously adapt, reflect, and align their actions with shared institutional visions.

LEARNING ORGANISATIONS

Recent research emphasises the significance of group and community-level learning, often prioritizing collaborative approaches over individual learning (Guanlao et al., 2025; Sharma & Nguyen, 2024). However, the mere presence of a group of learners does not automatically constitute a learning organisation. Contemporary studies emphasize two critical dimensions of organisational learning: first, the concept of shared cognition, which refers to the collective construction and utilization of knowledge within groups (Hansen, Jensen & Nguyen, 2020); and second, the organisation's capacity to operate as a learning entity that fosters continuous growth and adaptation. These perspectives highlight that effective learning extends beyond individual competence, requiring systemic structures and processes that enable collaboration and organizational responsiveness.

Several authors who have provided foundational theories on organisational learning. For example, Argyris and Schön (1996) explored how organisations adapt and improve, while Garvin et al. (2008) focused on implementation and innovation. Nevertheless, one of the most influential authors on this concept is Peter Senge, who outlined five key principles of a learning organisation.

Senge's model is structured around five interdependent disciplines necessary for an organisation to pursue learning (Senge et al., 2012). First, *Personal Mastery* involves clarifying and deepening employees' own personal vision and

seeing reality objectively. It is about personal growth and learning, contributing to the overall learning and development of the organization. Second, *Mental Models* is about challenging and refining deep-rooted assumptions and generalisations. They influence personal and organisational views and behaviours, often unconsciously. Third, *Shared Vision* involves creating a common goal that employees within an organisation want to achieve, fostering genuine commitment. Fourth, *Team Learning* promotes collective thinking and collaboration. It fosters a culture where team members learn from each other and work towards common goals. Fifth, *Systems Thinking* involves understanding how different parts of an organisation interrelate and influence one another. It encourages looking at patterns and structures that drive behaviour over time.

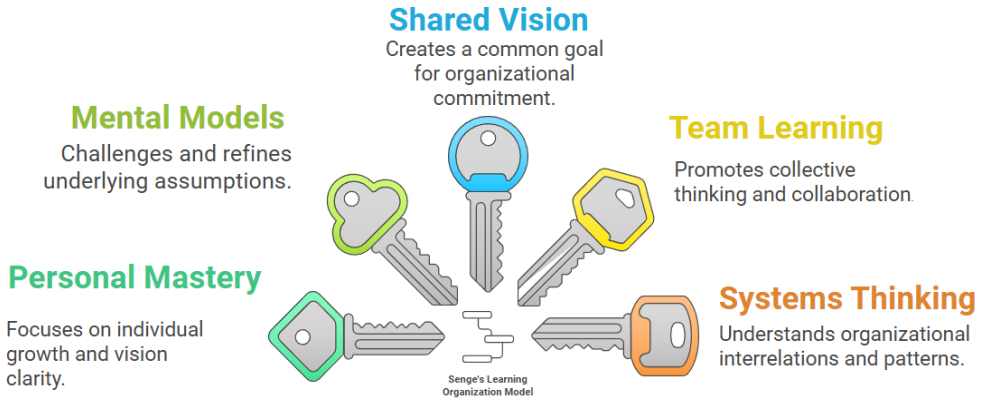

Figure 1. *Senge's Five Principles of a Learning Organisation*

True learning organisations are strategically committed to developing their capacities and sharing learning that benefits individuals and the entire organisation, making them more adaptable in ever-changing environment. Although HEIs are inherently knowledge-based institutions, Senge et al. (2012) argue that many do not operate as learning organisations due to siloed practices and limited collective learning.

Subsequently, the aim of this study is to enhance awareness of the multifaceted phenomenon of higher education institutions to transform into a learning organisation. By utilising Senge's (2006) learning organisation model as a theoretical framework, we explore its application in an African higher education context. This study therefore examines how UR and RP are developing characteristics of a learning organisation and whether digital-pedagogy training can support this transformation. The research questions were formulated as follows:

1. To what extent has the training offered supported the application of Senge's model towards a learning organisation?
2. How can the core principles of Senge's model be applied in the Rwandan higher education context?

METHODOLOGY

Research Design

This practice-based research adopted a qualitatively driven mixed-methods design (Frost et al., 2022) to gain contextual insights into how these two Rwandan HEIs are evolving into learning organisations. Participants in this study included university teachers from RP and UR's College of Education who were engaged in the digital pedagogical training. The training was delivered between December 2024 to March 2026 through both face-to-face sessions in Rwanda and online webinars.

Multiple data sources were collected during the training for triangulation and trustworthiness (Creswell, 2014). These sources included an online questionnaire and observational field notes during the training sessions. The online questionnaire was developed in collaboration with Rwandan and Finnish researchers. It was based on Senge's framework consisting questions of each of five categories: personal mastery, mental models, shared vision, team learning and systems thinking. It comprised 18 statements Likert-scale statements and two open-ended questions that focused on finding any challenges in applying the model, and support that would have been needed in application process. Questionnaire also had an option to give any comments or remarks. The online questionnaire was sent to all participants (n=21), and they were asked to offer they assessment anonymously. The questionnaire was answered by 11 participants. The collected data was analysed quantitative, using Webropol's analysis system and qualitative utilising content analysis techniques to understand what insights it provides (Creswell, 2014).

Results

Quantitative Findings

Answers to the statements demonstrate a strong positive impact across all five of Senge's learning-organisation disciplines. With n=11 respondents, the overall mean across all 18 Likert-scale items was 4.33/5, indicating strong perceived benefits from the training in their professional growth and teaching practices. The results in Table 1, indicate that the training had its strongest impact on personal mastery (4.50), mental models (4.43), and team learning (4.37).

Table 1. *Results of the Online Questionnaire*

Category	***Mean score***
Personal Mastery	4.50
Mental Models	4.43
Team Learning	4.37
Shared Vision	4.27
Systems Thinking	3.97
Overall (18 statements)	**4.33**

Personal Mastery showed the strongest results with participants reporting enhanced professional development (4.8), strengthened their ability to set new learning goals (4.5), and improved reflective capacity regarding personal strengths and areas for growth (4.6). Although perceptions of institutional support were somewhat lower (4.1), the domain overall demonstrated a positive impact on participants' motivation, confidence, and commitment to ongoing professional learning.

Mental Models also showed strong results, with average scores between 4.2 and 4.5. Respondents indicated that the training challenged their assumptions about teaching and learning (4.2), helped evolve their understanding of student learning (4.5), and increased their openness to questioning established practices (4.5). They also reported improved capacity for critical reflection on their own decision-making processes (4.5). Team Learning outcomes were similarly robust, with mean scores ranging from 4.2 to 4.5. Participants noted improvements in collaboration with colleagues (4.2), refinement of teaching strategies through peer discussions (4.4), and the strengthening a culture of mutual learning within their teams and departments (4.5). Taken together, these findings suggest that training effectively supported deeper pedagogical reflection, increased collegiality and stronger peer support, thereby contributing to a more collaborative professional environment.

The results for Shared Vision indicate a generally positive effect of the training, with mean scores ranging from 4.2 to 4.3 across the three items. Participants reported a clearer understanding of their institution's educational goals (4.3), a stronger sense of alignment with organizational values (4.2), and an enhanced perception of shared purpose among colleagues (4.3). Overall, the findings suggest that the training contributed to strengthening common direction and coherence within the organisation. Systems Thinking yielded more moderate results, with scores ranging from 3.8 to 4.2, making it the lowest rated domain. Respondents expressed limited confidence in understanding interdepartmental relationships (3.8) and the effects of changes across organisational units (3.9), although they rated slightly higher their ability to consider long-term implications of teaching related decisions (4.2). These results indicate that, while some progress was made, system level awareness and cross unit perspective taking remain areas requiring further development.

Qualitative Findings

Qualitative content analysis (Creswell, 2014) of the open-ended responses reveals several recurring challenges affecting participants' ability to apply learning from the digital pedagogy training. The most frequently cited constraints relate to limitations in individual mastery of new digital tools and pedagogical approaches. Several respondents reported that they had not yet fully internalised the techniques covered during the sessions and required additional opportunities for practice. Structural and contextual factors also emerged as salient barriers. Large class sizes and heavy workloads were repeatedly mentioned as restricting the time and flexibility necessary for effective integration of digital methods into teaching practice. Additionally, participants identified barriers associated with access to digital tools, both in terms of the availability of free versions and the lack of institutional licences

for premium features. Challenges related to institutional processes, unreliable internet connectivity, and resistance to change among colleagues or students further inhibited the adoption of new pedagogical practices.

When asked what forms of support would facilitate more effective implementation, respondents consistently emphasised the need for continued professional development. Requests centred on ongoing training, regular workshops, and structured opportunities for capacity building. A notable number of participants highlighted the importance of improved access to digital tools and premium software, alongside enhanced institutional internet infrastructure. Recommendations also included more practice-oriented support, such as weekly hands-on sessions or CPD activities focused on specific digital tools. A smaller set of responses indicated the need for greater managerial involvement, mentoring structures, and increased staffing to address workload pressures.

Overall, these responses that were also reflected in field observations, suggest that while participants are motivated to adopt new digital practices, sustained implementation requires a combination of skill reinforcement, improved institutional infrastructure, and stronger organisational support mechanisms.

DISCUSSION AND CONCLUSIONS

The findings demonstrate that Senge's learning organisation model, although originally developed for Western institutional contexts, can be meaningfully adapted to the Rwandan higher-education context. Prior research has shown that Senge's Five Disciplines is foundational for understanding how organisations can cultivate continuous improvement and adaptive capacity (Senge, 2006). The present study indicates that principles of a learning organisation can support pedagogical transformation even in resource-constrained environments characterised by uneven digital access, infrastructure limitations, and different institutional cultures. This aligns with literature highlighting the model's global adaptability across varied organisational settings, including higher education (Bui & Baruch, 2010). Successful implementation, however, requires gradual, context-sensitive approaches that respond to local cultural and structural constraints.

The training programme evaluated in this study appears to have strengthened capacities at the micro level, particularly in personal mastery, mental models and team learning. These findings echo research showing that Senge's first four disciplines are often the most accessible entry points for organisations to begin the journey for transformation (Sari, 2022). Participants reported enhanced motivation, deeper reflective practices, and increased openness to pedagogical change that are consistent with the documented role of personal mastery and mental models in stimulating individual learning and professional growth (Senge, 2006; Asgari & Dadashi, 2011). Meanwhile, improvements in shared vision and team learning reflect the early emergence of collaborative culture and collective pedagogical purpose, a pattern similarly observed in organisational case studies applying Senge's framework (Sari, 2022).

The results align closely with the objectives of Vision 2050 and NST2, which emphasize institutional innovation, accountability, and digitally competent human capital. While the training demonstrated strong gains at the individual and team levels, the relatively weaker development of systems thinking suggests that policy aspirations for integrated, system-wide transformation have not yet been fully realised. This is consistent with prior studies noting that systems thinking is the most difficult discipline to embed sustainably, particularly in complex and hierarchical institutions (Bui & Baruch, 2010). Senge's fifth discipline integrates the other four and requires organisational-level alignment, cross-unit collaboration, and shared responsibility for long-term change. As emphasised in the literature, without systemic awareness, institutions risk making progress only at the individual level without achieving deeper structural transformation (Bui, 2020). In practical terms, strengthening systems thinking will require deliberate institutional actions, including structured cross-departmental collaboration, leadership-supported reflective forums, and alignment of digital pedagogy initiatives with institutional strategies and performance indicators. In Rwandan context, embedding professional learning communities, linking CPD outcomes to institutional planning, and fostering shared accountability across academic departments could support this shift. This highlights the need for HEIs to move beyond project-based capacity building toward embedding learning-organisation principles within institutional governance, quality assurance mechanisms, and leadership practices.

Becoming a robust learning organisation necessitates long-term commitment, structured opportunities for reflection, and leadership-supported dialogue, conditions that are widely cited as essential in the literature (Senge, 2006; Sari, 2022). To evolve into fully developed learning organisations, Rwandan HEIs should therefore prioritise cultivating systems thinking, reinforcing shared institutional perspectives, and creating structures that support ongoing collaborative learning, such as professional-learning teams and cross-departmental dialogue. These recommendations align with broader African higher-education research that emphasises the potential for universities to foster cultures of shared learning, collegial support, and joint innovation.

Limitations

This study has several limitations that should be considered when interpreting the findings. First, the sample size was relatively small (n=11), which restricts the generalisability of the quantitative results and limits the extent to which the findings represent the broader populations of UR and RP. Second, participation in the training and the online questionnaire was voluntary, which may have introduced self-selection bias; those most motivated or positively inclined towards digital pedagogy may have been more likely to respond. Third, the study relied on self-reported perceptions, which can be influenced by social desirability bias and may not fully capture actual behavioural change in teaching practice. Fourth, the observational data were collected during training sessions facilitated by external partners, which may have shaped participants' engagement and does not necessarily reflect everyday institutional realities. Finally, the study examined short-term outcomes; longer-term research is needed to determine whether the observed improvements—particularly

in personal mastery, mental models, and team learning—translate into sustained organisational transformation and stronger systems thinking across HEIs**.**

Future Studies

Further research should examine how Senge's framework can be systematically adapted for resource-constrained educational environments. Future studies could explore which contextual factors, such as institutional culture, governance structures, or digital readiness most significantly shape the applicability of the model in African HEIs. Given the weaker performance in systems thinking, future research should investigate effective strategies for cultivating institutional interdependency awareness and cross-unit collaboration. Comparative studies across institutions may help identify organisational structures that best support systems-level learning.

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UTILIZING GENERATIVE AI FOR ONLINE COURSE CREATION

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ABSTRACT

Through a practice-based case study, this study explores the capabilities of generative AI in the comprehensive development and operation of online courses at a Japanese online university. Using AI tools including ChatGPT, Gemini, Deepbrain AI, and Napkin AI, we examined automated processes for generating syllabi, lecture slides, scripts, video content, quizzes, report assignments, and preliminary feedback on student work. The results demonstrate that generative AI can significantly reduce the time and effort required to create and manage courses. We also observed a high correlation between two generative AI raters (ChatGPT and Gemini; r=0.73) in evaluating student essays, alongside generally positive student acceptance of the AI-based lecture format (mean 3.8 out of 5). While the AI tools successfully generated substantial components of the course materials, challenges related to content accuracy, pedagogical appropriateness, and ethical considerations were consistently observed. Human oversight remained critical to ensure educational quality and integrity. This research contributes to practice-based educational research by providing a practical framework for AI-supported course development and proposing guidelines for ethical integration of AI in higher education.

INTRODUCTION

The integration of Artificial Intelligence (AI), particularly generative AI, into higher education has become an expanding area of scholarly investigation. The emergence of large language models such as ChatGPT, Gemini, and Claude has created new possibilities for educational content creation, assessment design, and learning support. These technologies offer potential solutions to persistent challenges in online education, including the substantial time investment required for course development and the need for scalable, adaptive content delivery (Alotaibi, 2024).

On-demand online universities face unique challenges in course development that differ from both MOOCs and conventional e-learning. Unlike MOOCs, which often target large-scale open enrolment with relatively standardized content and limited

degree-related assessment practices, on-demand online universities must deliver credit-bearing courses within a formal degree program, with clear learning outcomes, assessments, and quality assurance. Unlike typical e-learning that supplements campus-based teaching, on-demand programs require a largely self-contained learning experience that can function without real-time instructor intervention.

Unlike traditional face-to-face instruction, these courses require comprehensive preparation of video lectures, interactive materials, assessment items, and feedback mechanisms before the course begins. This front-loaded development process places significant demands on faculty time and resources, and the demands are amplified when courses are offered only on an on-demand basis.

Prior research has examined AI applications in educational settings, revealing both opportunities and limitations. Zawacki-Richter et al. (2019) conducted a systematic review of AI applications in higher education, finding that while AI technologies show promise, only 1.4% of 146 studies before the generative AI era addressed ethical concerns. More recent studies have explored generative AI's potential for course design and assessment, with Kim and Koo (2024) examining AI's influence on syllabus design and Khademi (2023) analyzing the reliability of AI-generated assessment items.

Despite growing interest, empirical studies examining the comprehensive application of generative AI across the entire course development and operation cycle remain limited, particularly in the context of on-demand online universities. This study addresses this gap by documenting a case study at Tokyo Online University, Japan, where generative AI tools were systematically employed to develop and manage a complete online course.

This paper makes three primary contributions: (1) it provides a detailed framework for AI-assisted course development across multiple phases; (2) it reports empirical findings on the effectiveness and limitations of AI tools, drawing on the creation of substantial end-to-end course content (approximately eight hours of video lectures and more than 120 assessment items, consisting of quiz questions and a report assignment) and on comparative grading results for that assignment. These results show high agreement between two AI raters (ChatGPT and Gemini; $r = 0.73$) and low agreement between two human instructors ($r = 0.29$). (3) it offers practical guidelines for educators seeking to integrate generative AI responsibly into their instructional design processes.

LITERATURE REVIEW

AI in Higher Education: Pre-Generative AI Era

Before the advent of generative AI, educational AI applications primarily focused on specific, well-defined tasks. Zhai et al. (2021) identified several dominant application areas: dropout prediction systems that identify at-risk students, automated essay scoring for efficient assessment, plagiarism detection tools, adaptive learning management systems, and intelligent tutoring systems that provide

personalized instruction. These applications represented significant advances in educational technology but required substantial development resources and technical expertise.

However, Zawacki-Richter et al. (2019) highlighted significant gaps in this research landscape. Their comprehensive review revealed that studies predominantly focused on technical implementation rather than pedagogical integration. Educators' perspectives were largely absent from the literature, and ethical considerations received minimal attention. Additionally, the high costs and technical expertise required for AI development limited accessibility for many institutions.

Generative AI and Course Development

The release of ChatGPT in November 2022 marked a paradigm shift in AI capabilities relevant to education. Unlike previous AI systems that performed specific, narrow tasks, generative AI demonstrates broad competencies in text generation, comprehension, and creative problem-solving. These capabilities have immediate implications for course development, as generative AI can assist with syllabus creation, learning material generation, assessment design, and feedback provision (Sok & Heng, 2023).

Nagy et al. (2024) characterized generative AI as a transformative partner in collaborative course development, noting that AI can serve as a brainstorming partner, content generator, and quality reviewer. Meron and Tekmen-Araci (2023) evaluated ChatGPT as a virtual colleague for postgraduate course development, finding that AI could generate valuable suggestions while human expertise remained essential for ensuring academic rigor. Early discussions have also highlighted generative AI's potential to support next-generation learning, while cautioning that educational design must preserve meaningful learning processes (Zhai, 2023).

Ethical and Quality Considerations

The integration of generative AI in education raises significant ethical and quality concerns. Crawford et al. (2023) emphasized the need for leadership in establishing ethical guidelines for AI use in education, highlighting issues of academic integrity, content validity, and transparency. Halaweh (2023) proposed strategies for responsible implementation, advocating for clear guidelines that address both the benefits and risks of AI-assisted education.

Cotton et al. (2024) and Dempere et al. (2023) examined the implications of AI for academic integrity, noting that while AI can support legitimate educational goals, it also creates new challenges for ensuring authentic student learning. Related work has also examined teachers' perspectives on ChatGPT-generated assignments, highlighting practical concerns about assessment and guidance (Dhamija & Dhamija, 2025). These concerns underscore the importance of human oversight and the development of assessment practices that leverage AI capabilities while maintaining educational integrity.

Institutional Guidelines and Student Communication in Our Study Context

In our study setting, the use of generative AI in educational practice was guided by the institutional guidance on appropriate use. In addition, we proactively communicated key points to students to ensure transparency and to support academic integrity (Sabzalieva & Valentini, 2023). Specifically, at the beginning of each video lecture, we provided a brief explanation of relevant cautions and expectations regarding generative AI use. We also included detailed notes in the course overview on the learning management system (LMS), clarifying practical considerations and points of attention for students.

RESEARCH CONTEXT

Tokyo Online University

Tokyo Online University (TOU) was established in April 2018. The university comprises two faculties: Information Management and Human Welfare. As of April 2025, the university serves 6,151 students, including credited auditors. The student body is characterized by its diversity in age (ranging from 18 to 80s, with an average age of around 35) and employment status (more than 70% maintain full-time employment while studying).

The university operates on a quarter system, with most courses offered twice annually. Instruction is delivered primarily through on-demand video lectures, supplemented by optional synchronous online sessions and limited in-person components. This delivery model requires extensive upfront course development, as all instructional materials must be prepared before the course opens.

Course Structure and Credit System

In the Japanese higher education system, a bachelor's degree requires 124 credits over four years, with one credit representing approximately 45 hours of study (equivalent to approximately 1.5 ECTS credits). At TOU, a one-credit lecture course consists of eight class sessions, each comprising four 15-minute video lectures followed by a 30-minute quiz. Additional components may include online discussions, report assignments, and a final examination.

This structure creates substantial development demands: a one-credit course requires approximately eight hours of instructional video content and more than 120 assessment questions. Because this institutional model requires extensive upfront preparation before course delivery, any reduction in development time directly translates into a disproportionately large impact on instructional efficiency. The development burden represents a significant challenge, particularly for faculty members who may teach multiple courses while fulfilling other academic responsibilities.

The TOU classes are briefly described below. As shown in Figure 1, each class unit consists of four 15-minute asynchronous video sessions, preparatory and review study, and a 30-minute quiz session. Some classes have online discussions or report assignments, and most classes are delivered on-demand.

As shown in Figure 2, each credit unit consists of eight classes, online discussions, a report assignment, and a final examination. TOU utilizes an academic quarter system, in which most courses run twice a year. Most students take between 30 and 40 credits per year.

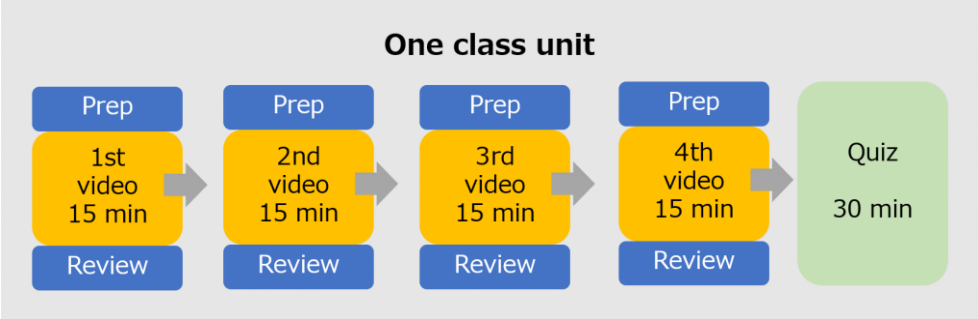

Figure 1. *The Structure of one Basic Class Unit*

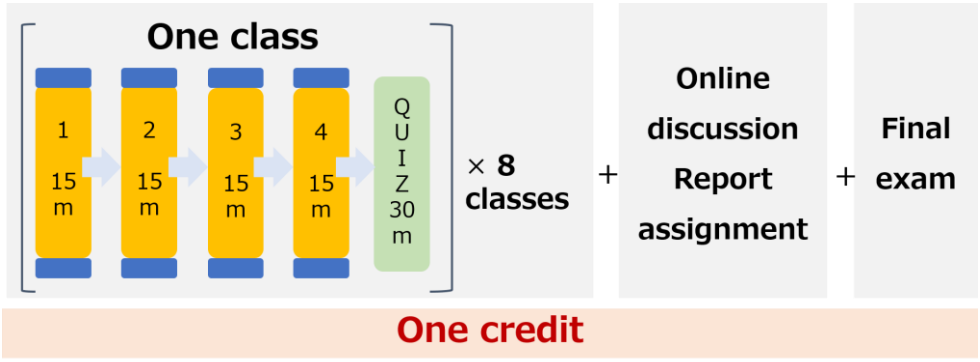

Figure 2. *The Structure of One Credit Unit*

RESEARCH QUESTIONS

This practice-based research addresses the following questions:

RQ1: In what ways can generative AI technologies support instructors' workload reduction in course design and assessment?
RQ2: Can interactive dialogue with AI support the creation of high-quality, academically rigorous course materials?
RQ3: Can AI reliably evaluate written assignments in ways that align with academic expectations and assessment criteria?
RQ4: Will students find an AI-generated course acceptable and aligned with their learning expectations?

METHODOLOGY

Research Approach and Positioning (Practice-Based Educational Research)

This study is positioned as practice-based educational research, drawing on an authentic teaching practice to produce transferable guidance for educators. Unlike design-based research, our work was not organized as multiple formal design–test–redesign cycles to validate design principles across repeated implementations. Unlike a conventional case study, we aimed not only to describe the case but also to synthesize reusable outputs. Accordingly, the case is used to derive an operational process model and checklist grounded in development logs, reflective memos, and learner feedback.

Research Design

A practice-based case study approach was employed in this research. The study focused on developing and implementing a new elective course titled "Advanced Topics in Management" for fourth-year university students. This course explores emerging technologies including blockchain and AI, covering their basic principles, managerial implications, and practical applications.

The development period spanned December 2024 to March 2025. Throughout this period, detailed logs and reflective memos documented the processes of creation and operation, providing data for subsequent thematic analysis. The course was delivered from April to May 2025, and evaluation—including report grading—was conducted in June 2025.

AI Tools and Development Process

Table 1. *AI Tools Used in Course Development*

Development Phase	AI Tools (From Dec. 2024 to Mar. 2025)
Syllabus Generation	ChatGPT (GPT-4o)
Slide Creation	ChatGPT (GPT-4o), Napkin AI
Script Writing	ChatGPT (GPT-4o)
Video Production	Deepbrain AI
Quiz Creation	ChatGPT (GPT-4o)
Report Assignment/Grading	ChatGPT (GPT-4o), Gemini (1.5 Pro, 2.0 Pro, and 2.5 Pro) (Grading process is in Jun. 2025)

Table 1 presents the AI tools employed across different phases of course development. ChatGPT served as the primary tool for text-based content generation, while specialized tools addressed specific requirements such as diagram creation (Napkin AI) and video production (Deepbrain AI).

Syllabus Generation

The syllabus development process began with interactive dialogue with ChatGPT to elaborate the course description and learning objectives. Through iterative refinement, the AI assisted in determining titles and overviews for all eight sessions, followed by detailed content planning for four lectures within each session. After assembling the complete structure, the instructor reviewed and adjusted the output, then consulted with the AI to check for completeness and identify any missing elements.

Slide and Script Creation

For each session, approximately 15 slide titles and outlines were generated through interactive dialogue with ChatGPT. When the AI produced information unfamiliar to the instructor, verification was conducted through reliable sources including academic papers, books, and authoritative websites. Inaccuracies were corrected before finalizing the materials. Napkin AI was utilized to create conceptual diagrams and visual representations of complex ideas (Figure 3).

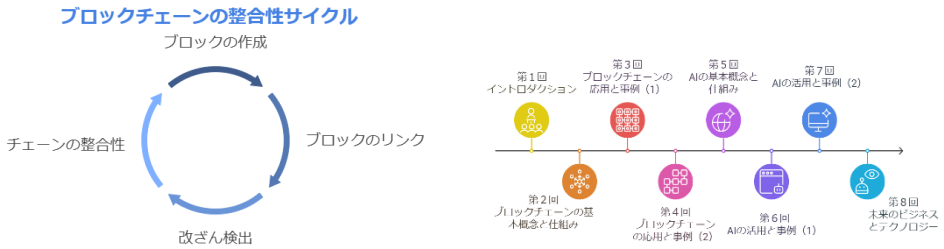

Figure 3. *Examples of Diagrams (in Japanese) Generated by Napkin AI*

Once slide content was completed, ChatGPT generated narration scripts for each slide. The instructor reviewed and revised these scripts, requested additional proofreading and refinement from the AI, and conducted a final review before proceeding to video production.

Video Production

Deepbrain AI was employed to generate video lectures featuring AI avatars (Figure 4). The PowerPoint files with embedded scripts were input into the system to produce videos. During the preview phase, particular attention was paid to pronunciation accuracy, as Japanese characters often have multiple possible readings depending on context. Manual corrections were made where necessary, and the audio was reviewed before exporting the final video files.

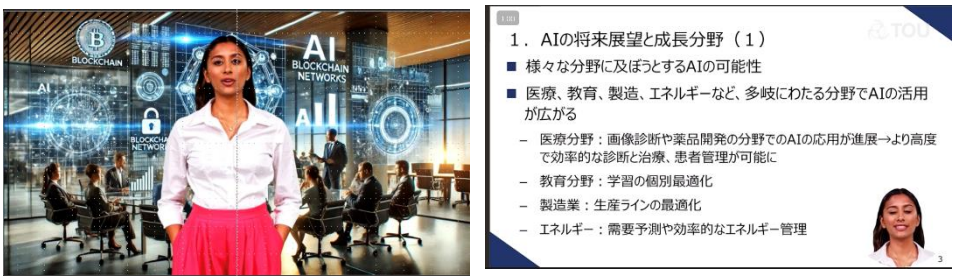

Figure 4. *Example of Video Images (in Japanese) Generated by Deepbrain AI*

Quiz and Assessment Creation

Quiz questions were generated for each session using the slide materials as context. Prompts were adjusted to ensure balanced coverage across all four lectures within each session, producing four-option multiple-choice questions. The instructor reviewed and revised the questions, the AI performed additional quality checks, and the instructor conducted a final verification before implementation.

For the report assignment, all slides were provided as context for the AI to propose suitable assignment options. The instructor selected one assignment—"Propose a new business based on the emerging technologies you learned in this course"—and the AI generated corresponding evaluation criteria (rubric) with five dimensions: Appropriateness of Technology Use, Validity of Problem Setting and Social Relevance, Concreteness and Feasibility of the Proposal, Differentiation from Competitors and Existing Services, and Logical Consistency of the Argumentation.

Data Collection and Analysis

Data collection encompassed three primary sources: (1) detailed logs and reflective memos documenting the development process, including representative prompts used for generating syllabi, slides, scripts, and quiz items, as well as operational records such as students' viewing/engagement status during course delivery, (2) student surveys (N=17) assessing acceptance of the AI-generated course, and (3) comparative analysis of assignment evaluations by four raters (two human instructors and two AI systems—ChatGPT and Gemini) for 74 student submissions. Thematic analysis was applied to the qualitative data from development logs and student feedback. For the assignment evaluation comparison, Pearson correlation coefficients were calculated to assess inter-rater reliability across all rater pairs.

RESULTS

Efficiency in Course Development (RQ1)

The instructors' reflections indicated that overall, the development of learning materials was carried out efficiently with AI assistance. The interactive dialogue approach enabled rapid generation of initial drafts for syllabi, slides, and scripts, which could then be refined through subsequent iterations. However, a precise

measurement of time savings was not conducted in this study. In this initial implementation, we prioritized demonstrating the practical feasibility of AI-supported course creation and capturing the instructors' perceptions of usability and constraints through reflective logs, rather than conducting controlled time-tracking across tasks and tools. Therefore, efficiency gains were assessed primarily through reflective logs, and systematic quantitative evaluation of workload and time reduction was deferred to future work.

However, some additional time was required for fact-checking and verifying the accuracy of AI-generated information. Particularly for technical content related to blockchain and artificial intelligence, verification against authoritative sources was essential. Checking pronunciation in the audio materials also required time, though editing AI-generated audio proved easier than recording and editing the instructor's own voice.

Quality of AI-Generated Materials (RQ2)

While AI tools successfully generated substantial components of the course materials, several quality concerns emerged. Factual accuracy required verification, as AI occasionally produced outdated or slightly inaccurate technical information. Content completeness was generally adequate, though some topics required elaboration beyond the AI's initial output. Alignment with learning objectives required careful review to ensure coherence across materials.

The AI-generated videos presented specific challenges. Student feedback highlighted issues with voice quality, including unnatural or monotonous intonation and awkward Japanese pronunciation. Some students noted that the AI avatar's body language, particularly the gesture of putting hands in pockets, felt culturally inappropriate in a Japanese authentic educational context. However, a few students found the AI voice clearer and more neutral than human instructors, helping them focus on the content.

AI-Assisted Assignment Evaluation (RQ3)

Table 2 presents the correlation coefficients among the four raters evaluating 74 student assignments. To support interpretation, we consider these correlations as complementary descriptive indicators of rater agreement, while noting that inter-rater reliability in writing assessment is commonly examined using more formal indices (e.g., inter-rater/intra-rater reliability and ICC; Rouhiathar & Howard, 2024). Notable findings include a high correlation (r=0.73) between the two AI systems (ChatGPT and Gemini), suggesting consistency in how AI tools apply the evaluation rubric. In contrast, the correlation between the two human instructors was relatively low (r=0.29), suggesting potential ambiguity in rubric interpretation and the need to review and refine the rubric and calibration process. This contrast also raises an important practical question: for assignments where even human raters disagree, it is necessary to discuss when (and when not) AI-assisted evaluation should be used, and how AI outputs should be positioned (e.g., as preliminary feedback rather than final judgment).

Table 2. *Correlation Coefficients Among Four Raters (N = 74)*

	Teacher A	Teacher B	ChatGPT	Gemini
Teacher A	-	0.29	0.54	0.54
Teacher B	0.29	-	0.27	0.41
ChatGPT	0.54	0.27	-	0.73
Gemini	0.54	0.41	0.73	-

The AI-human correlations showed moderate values (ranging from 0.27 to 0.54), with Teacher A showing stronger alignment with both AI systems than Teacher B. These results suggest that while AI can provide consistent preliminary evaluations, the variation between human raters indicates the importance of establishing clearer evaluation criteria and considering multiple perspectives in assessment.

Student Feedback (RQ4)

The preliminary survey of student feedback (N=17) asked whether students could evaluate the overall lecture format using AI agents positively. The total number of enrolled students in the course was 94. Responses were collected anonymously, and therefore no demographic or background information about the respondents was available. Responses on a 5-point scale yielded an average of 3.8 (Table 3). The standard deviation of 1.1 indicates moderate variability in responses, with the majority of students (10 out of 17) rating the format positively (4 or 5).

Table 3. *Student Feedback on AI-Based Lecture Format (N = 17)*

Scale	Response	Number of Students
5	Very positive	6
4	Somewhat positive	4
3	Neutral	4
2	Somewhat negative	3
1	Very negative	0
	Average score:	**3.8**

Qualitative feedback revealed several themes. Students appreciated the innovative approach and found the AI-generated content informative. Several students noted that the experience provided helpful insights for understanding AI applications in their own work. Suggestions for improvement included offering multiple voice options or different AI agents to accommodate individual preferences, improving facial expressions and gestures synchronized with key points in the lecture, and addressing cultural considerations in avatar design and behaviour.

DISCUSSION

Addressing Research Questions

Regarding RQ1, the findings indicate that generative AI can substantially accelerate content development and reduce preparation time compared with conventional manual methods. The efficiency gains were most pronounced in initial draft

generation for text-based materials, while verification and refinement still required significant instructor time.

For RQ2, the interactive dialogue approach proved effective for generating course materials of acceptable quality, though human expertise remained essential for ensuring academic rigor, verifying factual accuracy, and maintaining pedagogical coherence. AI served effectively as a collaborative partner rather than an autonomous content creator.

The results for RQ3 present a mixed picture. AI systems demonstrated high consistency with each other but moderate alignment with human evaluators. The relatively low inter-rater reliability between human instructors suggests that clearer rubrics and calibration processes may be needed before AI evaluation can be reliably integrated into assessment workflows.

Concerning RQ4, the generally positive student response (average 3.8 on a 5-point scale) indicates tentative acceptance of AI-generated courses, though feedback highlighted areas for improvement, particularly regarding voice quality and cultural appropriateness of avatar behaviour.

While our students' reactions to the AI avatar–based lectures were generally positive, this pattern appears to differ from the findings reported by Arkün-Kocadere and Çağlar-Özhan (2024). Our results should also be interpreted alongside other recent experimental evidence comparing human-made and AI-generated teaching videos (Netland et al., 2025). At the same time, a direct comparison should be interpreted with caution because multiple conditions are likely to vary across studies, including the technical quality of the video and audio, learners' prior acceptance of AI-generated instructors, and course design features such as perceived relevance and the extent to which learning activities are linked to assessment. Notably, Arkün-Kocadere and Çağlar-Özhan (2024) also indicated that when learners are highly interested in the content or when the learning experience is meaningfully connected to evaluation, students may pragmatically consider AI-instructor videos to be "usable" in practice. Taken together, our findings may tentatively suggest that some degree of acceptability of AI avatar-mediated instruction can be observed in different contexts, although the level of positivity is likely to remain contingent on quality- and design-related factors.

Implications for Practice

This study offers several implications for educators considering AI integration in course development. First, AI is most effectively positioned as a collaborative tool rather than a replacement for instructor expertise. The iterative dialogue approach—generating, reviewing, refining, and verifying—leverages AI capabilities while maintaining human oversight.
To enable reuse by other instructors (not only the original course team), this "iterative dialogue" should be operationalized as a lightweight, repeatable process model and a minimal checklist that can be applied across different subjects.

Reusable Process Model (Iterative Dialogue for Course Development)

- Define constraints (human-led): course context, learner profile, outcomes, institutional rules, time budget.
- Generate (AI-led): produce a first draft artifact (syllabus, slides, script, quiz, rubric) with explicit assumptions.
- Review (human-led): check alignment with outcomes, level, coverage, and internal consistency.
- Refine (AI + human): request targeted revisions with clear acceptance criteria (e.g., "keep outcomes fixed, simplify jargon, add examples").
- Verify (human-led, evidence-based): fact-check key claims, citations, calculations, and policy/ethics compliance.
- Package for reuse (human-led): store prompts, inputs, outputs, and decision notes as a reusable "module" (template + rationale + sources).

Minimal Checklist for Reuse by Other Instructors

- Learning outcomes and assessment alignment are explicit (what is taught, what is tested).
- AI prompts, inputs, and tool settings are recorded so the process is reproducible.
- High-risk claims (numbers, definitions, regulations, rapidly changing topics) are verified against reliable sources.
- Cultural/contextual appropriateness is checked (language, examples, tone, visuals/avatars).
- Academic integrity and ethics are addressed (bias, originality, disclosure, data privacy).
- A 'handoff note' documenting what was changed by the instructor and why (to support future reuse).

Second, verification processes must be built into AI-assisted workflows. Time saved in initial content generation may be partially offset by verification requirements, particularly for technical or rapidly evolving subject matter. Institutions should develop protocols for fact-checking AI-generated content.

Third, cultural and contextual considerations require attention when using AI tools developed primarily for English-language contexts. Pronunciation systems, body language norms, and presentation conventions may require adaptation for different educational contexts.

Limitations

This study has several limitations. As a single-course case study drawn from a single elective course and conducted by two instructors, the findings may not generalize to other contexts, subjects, or instructional approaches. The quantitative measurement of time savings was not systematically conducted, limiting the ability to precisely

assess efficiency gains. The student feedback sample (N=17) was small, and results should be interpreted cautiously. Additionally, the rapid evolution of AI capabilities means that findings based on tools available in late 2024 and early 2025 may not reflect current or future capabilities.

CONCLUSION AND FUTURE WORK

This case study examined the application of generative AI across the complete cycle of online course development and operation at a Japanese online university. The findings demonstrate that generative AI offers significant potential for improving instructional efficiency while highlighting the continued importance of human oversight for ensuring educational quality and integrity.

Key conclusions include: (1) Generative AI substantially accelerates content development, though verification and refinement require continued instructor involvement; (2) Quality assurance—including factual verification, alignment with learning objectives, and attention to ethical considerations—requires systematic review processes and responsible implementation frameworks; (3) Students show tentative acceptance of AI-generated courses while identifying specific areas for improvement.

Future research will pursue three directions. First, we will develop an educational chatbot that students can actively use to support their learning, including course Q&A, study guidance, and personalized learning assistance. Second, we will conduct quantitative evaluation of workload reduction to provide more precise estimates of efficiency gains. Third, we will review and redevelop rubrics using inter-rater reliability measures (including ICC and related inter-rater reliability analyses) to improve the consistency and validity of AI-assisted grading. In addition, we will refine and validate a reusable process model and checklist for AI-assisted course development (e.g., logging prompts and decisions, quality and compliance checks) through application by multiple instructors across different courses, examining reproducibility, efficiency, and quality outcomes.

This research contributes to practice-based educational research by providing a practical framework for AI-supported course development, highlighting potential risks and suggesting mitigation strategies, and proposing guidelines for the ethical integration of AI in education. As generative AI capabilities continue to advance, ongoing research will be essential to realize the benefits while addressing the challenges of AI integration in higher education.

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LEARNING FROM THE IMPACT OF COVID-19: PRACTICAL LESSONS FOR FUTURE DISTANCE LEARNING

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ABSTRACT

This contribution examines the educational impact of COVID-19-related school closures across several sub-studies conducted within a Swiss research project and derives practical implications for the future design of distance learning. The project addresses the question of how to structure crisis-induced distance learning in ways that supports both learning and student well-being, employing a multi-method approach. Quantitative analyses of data from digital learning tools suggest that school closures should be kept as short as possible. Also, a "digitization boost" was observed, reflecting an increased use of digital tools and highlighting the need for pedagogically grounded support frameworks to guide their classroom application. A student survey (N = 1,224) yielded nuanced insights: multivariate regression analyses identified students with weaker independent learning behaviours and lower socioeconomic status as particularly vulnerable in terms of well-being and learning success. Confirmatory factor and latent profile analyses showed a strong link between students' well-being and learning success, implying that promoting well-being may also enhance learning and vice versa. Analyses also identified substantial heterogeneity in students' ability to adapt to new learning conditions. Responses to open-ended questions emphasized the need to plan distance learning holistically and to cultivate learner independence under regular conditions. Qualitative interviews with N = 16 teachers underscored the critical roles of family support and student self-regulation for learning success, while student well-being was heavily affected by contact restrictions. Based on these results, we propose a usage model that offers practical guidelines that prioritize student well-being, foster independent learning skills, and encourage meaningful use of digital media to better prepare schools for future disruptions.

INTRODUCTION

School closures implemented to contain the COVID-19 pandemic caught many education systems largely unprepared (Helm et al., 2021) and posed major challenges for all actors in the school system. Neither school administrators nor education authorities had guidelines for organizing instruction under these conditions. Because schools were required to maintain instruction to fulfil their social mandate (Hume et al., 2022) and compulsory-education obligations, a wide range of distance learning concepts emerged at the beginning of the pandemic (Beyer et al., 2020). Previous studies examining the effects of distance learning have reported stagnation or declines in student learning outcomes (e.g. Jakubowski et al., 2025; Wisenöcker et al., 2025) as well as declines in student well-being (e.g. Essler et al., 2024; Schiera et al., 2024). In addition, students differed substantially in their ability to cope with the unfamiliar situation, which may have contributed to a further perpetuation of negative influences of distance learning on certain groups of students (Brauchle et al., under review).

Although the COVID-19 pandemic appears to have subsided, the likelihood of future comparable situations remains high due to local (Zviedrite et al., 2024) and global disease waves (Marani et al., 2021), as well as extreme weather events (Clarke et al., 2022). Recent examples include the floods in Spain in autumn 2024 and the wildfires in Los Angeles in winter 2025, which led to local school closures and necessitated the reintroduction of distance learning (Jones, 2024; Mpoke Bigg, 2025). It is therefore important to examine the impact of the COVID-19 pandemic in order to derive lessons for future situations of distress and thus avoid negative consequences similar to those observed during the pandemic (Huber et al., 2023).

This research project, entitled *Learning from the Impact of Covid-19 on Educational Practice to Expedite Pedagogically Meaningful Digitization* and conducted within the Swiss National Research Program (NRP)80 *COVID-19 in Society* (funded by the Swiss National Science Foundation, grant number 408040_210193), examines the effects of pandemic-related school closures with the aim of deriving lessons for future comparable situations. The overarching research question is: How can distance learning be established in future crisis-induced school closures in a way that supports student learning and maintains student well-being? To this end, the project applies a multi-method design that integrates multiple data sources and combines quantitative and qualitative methods.

THEORETICAL AND EMPIRICAL BACKGROUND

This section reviews theory and evidence on students' learning success and well-being during COVID-19, providing the basis for the research project presented next.

Student Learning Success During COVID-19

Various international studies have demonstrated negative effects of distance learning on students' learning success, so-called "learning losses" (e.g. Jakubowski et al., 2025; Wisenöcker et al., 2025). However, considerable variation in the extent of

learning losses across studies has been reported (Betthäuser et al., 2023). Notably, some students achieved better learning outcomes during school closures, whereas others experienced marked difficulties (Major et al., 2024).

Distance learning was characterized by a high proportion of independent work and a low proportion of direct communication (Helm et al., 2021). According to scaffolding theory, this reduced interaction limited opportunities for cognitively stimulating intermental and social learning processes. This leads to a shift in learning towards less stimulating intramental activities (Brauchle et al., 2025; Pol et al., 2010). Accordingly, students spent a large proportion of their time either solving tasks they had already mastered or struggling with unfamiliar tasks that overwhelmed them.

Due to the predominance of independent work, students also needed a high degree of self-regulation to manage distance learning effectively (Brauchle & Unger, in preparation). Difficulties with self-regulation can result in procrastination and other learning-related challenges (Engberding et al., 2017).

Student Well-Being During COVID-19

Over the course of the pandemic, studies identified declines in life satisfaction and increases in stress and anxiety among students (Zdravkovic & Goldstein, 2023; Ravens-Sieberer et al., 2022). In addition, rates of depressive and anxiety symptoms, incidences of hyperactivity and oppositional behaviour, and peer-related problems were found to have risen, while health-related quality of life declined (Döpfner et al., 2021; Laubstein & Scheer, 2022).

The loss of school as a place for peer interaction and social contact had a substantial impact on student well-being (Letzel-Alt et al., 2022). Such social contacts represent an important protective factor against mental illness and are associated with more positive emotions and enhanced well-being (Ryff et al., 2021; Schmidt et al., 2019).

Beyond the lack of social contacts, the discontinuation of extracurricular activities also contributed to deteriorations in mental health (Schiera et al., 2024). Many students further perceived the resulting monotony negatively (Brauchle et al., 2024). Uncertainty about the progression of the pandemic and potential future restrictions further compromised student well-being.

In contrast, only a few studies identified potentially beneficial effects of school closures on well-being. These included reduced perceived stress, a decline in bullying, and fewer social conflicts (Döpfner et al., 2021; Vaillancourt et al., 2021). Some students also appreciated the opportunity to sleep longer during distance learning, which can have beneficial effects on well-being (Brauchle et al., 2024; Wacker & Unger, 2021).

THE RESEARCH PROJECT

This section systematizes the project's findings to inform preparedness for future crisis conditions, including potential school closures. The practical application of the lessons learned follows after this section.

Analysis of Standardized Learning Tests *(summary of Unger et al., under review)*

To investigate the impact of distance learning on students' learning progress in Switzerland, the project analysed data from $N = 24{,}827$ students who participated in the standardized assessment "Lernpass Plus". This computer-adaptive assessment is mandatory in Grade Levels (GL) 8 and 9 in some German-speaking cantons. Data from the subjects mathematics, German, English, and French were included in the analysis. The dataset allows for the examination of learning gains from GL 8 to GL 9 over the course of the COVID-19 pandemic (first tests in GL 8 in spring 2019 and second test in GL 9 in spring 2020, immediately after school closures – the "COVID-cohort") and over four subsequent years. Additionally, the Lernpass Plus data were analysed to explore indications of a possible "digitization boost" in schools.

Impact of the Pandemic on Learning Success

Using longitudinal multiple-group item response models (Azevedo et al., 2015) and dichotomous 1PL (Rasch) measurement models (McArdle et al., 2009), we estimated learning gains from GL 8 to GL 9 and compared them between the "COVID-cohort" and subsequent cohorts. Unlike findings from other studies (e.g. Wisenöcker et al., 2025), we did not identify reduced learning gains ("learning losses") among students directly affected by the pandemic compared to later cohorts. In contrast, higher learning gains in mathematics, German, and English were found in the cohort one year after school closures (first tests in GL 8 in spring 2020, immediately after school closures and second tests in GL 9 one year later). Given the relatively short duration of school closures in Switzerland (UNESCO, 2022), these findings align with other studies that demonstrate a correlation between the duration of school closures and the occurrence of learning losses during the pandemic (Patrinos, 2023). In future comparable situations, school closures should therefore be kept as short as possible to minimize negative effects on learning outcomes.

Effects of School-Level Variables on Learning Success

The examined models were extended with regression analyses to assess the effect of average family income, the proportion of students receiving municipal social assistance, the average highest educational qualifications of parents, and the proportion of students who do not speak German at home on learning gains during the pandemic. These variables were aggregated at the school level to examine whether between-school differences affected students' learning success. This perspective is particularly relevant as crisis management decisions are initially made

at the school meso-level, and we sought to generate evidence on possible school-contextual risk factors in implementing distance learning. But no consistent effects of these variables on learning success were identified across cohorts and subjects.

Use of Digital Learning Media

In addition to the high-stakes tests, the "Lernpass Plus" platform provides low-stakes tests that teachers can use to practice specific content. Analyses of practice-test usage frequency – using time series decomposition and change point detection (Zhao et al., 2019) – revealed a marked increase in the use of digital learning media during school closures. This increased use persisted after schools reopened, indicating a sustained increase in digital learning media use and suggesting a COVID-19-related "digitization boost". However, our data didn't allow for an assessment of how effectively digital tools were integrated into teaching–learning scenarios.

Analysis of the Student Questionnaire "My Corona Diary"

We examined the students' perspective on pandemic-related school closures via secondary analyses of the online questionnaire "My Corona Diary" (collected via SoSci Survey, Leiner, 2022), administered between April 5 and July 22, 2022. Data from N = 1,224 students from Germany and Switzerland were analysed.

Factors Affecting Student Learning Success and Well-Being (summary of Brauchle et al., 2025; Brauchle & Unger, in preparation)

Using latent-modelled stepwise regression analyses, we investigated factors influencing students' learning success and well-being during the pandemic. Learning success was assessed via current report-card grades in math and German, as well as by students' self-assessed learning success during the pandemic compared to instruction before the pandemic. Well-being was modelled according to Diener's (1994) definition and the associated bottom-up theory (Diener & Ryan, 2009), using indicators of general life satisfaction, perceived stress, and the frequency of pandemic-related anxiety. Students with lower self-assessed self-regulation and those reporting insufficient teacher support showed lower levels of both learning success and well-being. Students whose parents had lower levels of education showed reduced learning success, whereas female students and those with less well-equipped home learning environments reported lower levels of well-being. These findings help identify students who were particularly vulnerable during the pandemic and should therefore receive targeted support in future comparable situations.

Correlation Between Well-Being and Learning Success (summary of Brauchle et al., under review)

A confirmatory factor analysis identified a positive correlation of r = 0.424 between well-being and learning success (each construct modelled as described above). This moderate correlation suggests a close relationship: students with higher well-being tend to achieve better learning outcomes (Fredrickson, 2001), and students with

higher learning success report higher well-being (Ryan & Deci, 2000). The higher correlation during the pandemic compared with correlations observed under normal conditions (Bücker et al., 2018), indicates that distance learning may have reinforced this reciprocal relationship. These findings highlight the importance of considering learning success and well-being jointly during distance learning. An exclusive focus on academic content, as was observed during the pandemic, appears unproductive and insufficient (Wacker & Unger. 2021).

Profiles of Students in Terms of Well-Being and Learning Success (summary of Brauchle et al., under review)

Latent profile analyses (Weller et al., 2020; Bakk & Kuha, 2021) identified four distinct student profiles based on their learning success and well-being:

- Profile 1 (26.2%): above-average learning success, but low well-being.
- Profile 2 (18.0%): lowest learning success and lowest well-being (represents the highest-risk group).
- Profile 3 (30.0%): below-average learning success, but higher well-being than Profiles 1 and 2.
- Profile 4 (25.8%): highest learning success and highest well-being.

Achieving the largest possible share of students in Profile 4 should be the goal during distance learning. The results further illustrate that students' capacity to cope with the challenges of pandemic-related distance learning varied considerably.
Regression analyses based on profile membership showed that students with lower self-regulated learning skills were more likely to belong to Profiles 1–3 than to the favourable Profile 4. Students with less well-equipped home learning environments and female students were more likely to be assigned to Profiles 1 and 2, those with the lowest well-being. Older students were more likely to belong to Profiles 2 and 3, which were characterised by lower learning success. These analyses support the findings of the regression analyses above and provide further indications of vulnerable student groups.

Students' Perception of Distance Learning (summary of Brauchle, Unger Grünig et al., in preparation; Brauchle, Unger, Hochweber et al., in preparation)

Given that well-being is a subjective and multifaceted phenomenon (Diener 1984), two open-ended questions – "What did you like about distance learning? What do you think could stay the same?" and "What did you not like about distance learning?" – were analysed to gain more nuanced insights into students' experiences of well-being during distance learning. Students primarily highlighted benefits associated with being at home, particularly the opportunity to sleep longer. They also appreciated the increased independence and flexibility, more frequent use of digital learning media, and fewer distractions while learning at home.

In contrast, negative experiences included the loss of school as a place of social interaction and peer contact, as well as reduced access to direct learning support. Many students also reported an increased workload, challenges with motivation and concentration, monotony, and excessive screen time.

The positively perceived aspects provide insights into how teaching under regular conditions might be adapted to better support student well-being. The negatively perceived aspects, on the other hand, underscore the importance of school as a social space, the need for appropriate task design, and the necessity of adapting teaching and learning concepts to the specific constraints of distance learning. Analyses of which students mentioned specific aspects revealed considerable heterogeneity, highlighting the highly individual nature of students' experiences during the pandemic.

Interviews with Teachers

Semi-structured interviews were conducted with $N = 16$ teachers from different language regions and school types in Switzerland. The interviews were analysed using content-structuring qualitative content analysis following Kuckartz and Rädiker (2024).

Impact on Learning Success (summary of Brauchle et al., under review)

According to the interviewed teachers, students' self-regulation skills exerted the strongest influence on learning success during the pandemic. Self-regulation was mentioned 25 times in connection with higher learning success, and 8 times in relation to lower learning success due to difficulties with self-regulation. Teachers also emphasized the importance of family support. They referred to family support 11 times as a factor contributing to better learning outcomes, while lack of such support was mentioned 9 times in connection with lower learning success. Furthermore, students' digital media literacy was cited 10 times as having a positive influence and 6 times as a barrier when digital competencies were lacking.

Impact on Student Well-Being (summary of Brauchle et al., under review)

With regard to student well-being, teachers most frequently referred to the effects of contact restrictions and students' ability to cope with them. Coping strategies such as online interaction with peers were mentioned 5 times in association with higher well-being, whereas negative effects of contact restrictions were cited 18 times. Teachers also highlighted the role of students' pre-pandemic mental stability, with one mention linking it to higher well-being and 13 mentions associating low pre-pandemic stability with reduced well-being. Self-regulation was again noted, with 9 mentions connecting it to higher well-being and 3 mentions linking difficulties with self-regulation to lower well-being.

TRANSFER OF RESEARCH RESULTS INTO A PRACTICAL USAGE MODEL *(summary of Unger & Brauchle, in preparation)*

To ensure that the research results can be applied in practice, the project aims to develop a usage model[1] with concrete guidelines, summarized in the form of a flyer. To this end, the results described above were first discussed at a meta-level with a stakeholder group from research and practice. Key issues to be addressed in future comparable situations were identified with the aim of supporting more effective distance learning while also promoting student well-being. These identified issues were then elaborated, and concrete recommendations were formulated regarding how to address them in future distance learning contexts. Based on these recommendations, a set of reflection questions was developed for teachers and school administrations to use when planning instruction under crisis conditions (for example in the form of a "contingency plan"). This format encourages reflection on the one hand and, on the other, allows teachers and school administrators to tailor decisions to local contexts. Additional practical tips were formulated for teachers to apply flexibly as needed. We gathered feedback on the content of the flyer in several expert panels and then further developed it.[2,3] Validation phases using a modified Delphi method (Hasson et al., 2025) are still pending.

CONTENTS OF THE USAGE MODEL

Below, we briefly present and explain the flyer's key issues, which are derived from our research findings and discussions with experts from academia and educational practice.

The Role of School and Teaching

School and teaching encompass more than the transmission of knowledge – they also provide spaces and opportunities for friendship and socialisation. Contact with peers and the associated socialization effects play a particularly important role in adolescence. Future distance learning should therefore be designed to intentionally incorporate opportunities for (digital) social interaction, such as group projects, informal exchanges, or discussion sessions – even if this entails a certain reduction in curricular content. Given the close link between learning progress and student well-being in distance learning settings, lesson planning should adopt a holistic approach. Short movement breaks and similar activities can help students step away from the screen, engage in physical activity, and reduce monotony.

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[1] We use "usage model" to denote a practice-ready synthesis of evidence-based conclusions.

[2] For example, feedback from our EAPRIL 2025 conference presentation in Malta informed subsequent revisions to the flyer.

[3] We would like to take this opportunity to express our sincere thanks to all the experts who provided us with feedback on the flyer, which contributed significantly to its further development.

Recognizing and Taking Into Account Particular Vulnerability Among Students

As the COVID-19 pandemic has clearly shown exemplarily, crises do not affect all students equally. It is therefore essential to consider students' socioeconomic, demographic, and family backgrounds to identify potentially vulnerable students at an early stage and reduce barriers to participation. This may involve providing appropriate learning environments and access to digital devices. Establishing and maintaining consistent communication channels with parents and guardians is also crucial; for this purpose, AI-based translation tools can help overcome language barriers.

Set Appropriate Tasks

A direct transfer of instructional tasks from regular classroom teaching to distance learning is inadequate, given the specific logic and constraints of remote instruction. Action-oriented tasks and individual or cooperative project work are more suitable, as they allow students to set their own priorities and work at their own pace. Such tasks also encourage students to take breaks from screens and engage in social forms of learning. Because students vary in their capacity for self-directed learning, tasks should be adapted and differentiated to their ability levels. A variety of social forms, methods, and task types is recommended to ensure variety. Organizing content into dossiers can help structure learning and support independent work.

Observing Students' Learning Behaviour

To identify difficulties with independent learning at an early stage and take appropriate countermeasures, it is advisable to observe students' learning behaviour. Difficulties in this area can lead to procrastination, which is associated with negative effects on both learning success and well-being. Therefore, promoting self-regulation should be a pedagogical priority even under regular conditions.

Structuring Lessons

As school provides students with a reliable daily routine, this structure should be preserved as much as possible during distance learning. A specially adapted timetable, developed in response to crisis conditions and coordinated across teaching staff, is recommended. For example, a brief joint check-in in the morning can help provide orientation and clarify initial questions. During the subsequent independent work phase, students should have access to low-threshold support options while maintaining the ability to work independently. A joint check-out in the afternoon allows for addressing remaining questions and closing the school day together. In addition, a consolidated weekly overview can helps students keep track of tasks, appointments, and deadlines.

Targeted Use of Digital Media

As digital media are central to digital lessons, their competent and confident use should be practiced under regular conditions to ease the transition to distance learning during crises. This is especially relevant given that our findings indicated a quantitative "digitization boost" during the pandemic, which underscores the need to align increased digital tool use with pedagogical quality. It is advisable to focus on a limited number of well-established tools rather than overwhelming students and teachers with a wide array of tools. At the same time, excessive screen time can negatively impact concentration and well-being. Therefore, distance learning should also include offline tasks that encourage students to step away from the computer, such as writing by hand or the above-mentioned project work approaches.

HOW TO WORK WITH THE USAGE MODEL

In the present section, we describe how the flyer can be used to develop teaching under crisis condition, using the flyers' section "The role of school and teaching" as an example (Figure 1).

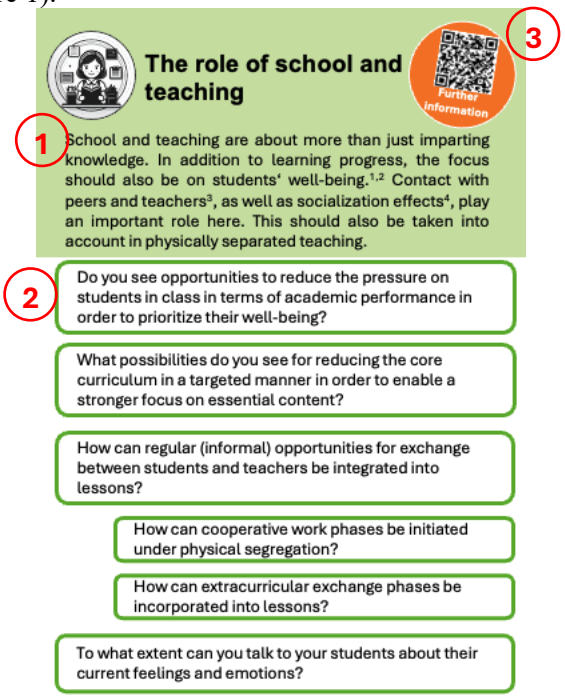

Figure 1. *Example Representation of the Section "The Role of School and Teaching" from the Flyer.*

The brief text (1) provides a concise overview of the current state of knowledge on this topic. The reflection questions (2) can be used to support the planning and design of teaching under crisis conditions. The QR code in the upper-right corner (3) provides access to additional information, including a more detailed overview of the scientific state of knowledge, practical suggestions for addressing the reflection questions, and the references cited in the text. The information accessible via the QR code will be updated regularly to reflect the evolving state of knowledge. The usage model offers teachers a framework to follow in the event of renewed crisis situations that require physically distanced teaching. In addition, incorporating the topics

addressed in the flyer into teacher education and professional development programs is strongly recommended, as this can help prepare prospective and in-service teachers for future disruptions – and reduce the risk of feeling overwhelmed, as was frequently observed during various phases of the COVID-19 pandemic.

CONCLUSION

Our study investigates the impact of COVID-19-related school closures with the aim of deriving lessons for improved preparedness in future crisis scenarios. Our goal is to prevent schools from facing the same level of overwhelm experienced during the first COVID-related closures, which led to a wide range of distance-learning concepts (Beyer et al., 2020) and prompted students to articulate clear demands for improvement (Wacker et al., 2020). A comparison between the first and second school closures in Germany indicates that qualitative development in distance learning is achievable, as students reported significant improvements over time (Unger, Schmidberger et al., 2025). Situations of distress that, like the pandemic, may lead to local or global school closures are expected to increase in the future, due to recurring waves of illness (Marani et al. 2021) or extreme weather events (Clarke et al., 2022). It is therefore highly relevant to systematically analyse the experiences of the pandemic and derive practical conclusions from them.

Our work within the project "*Learning from the Impact of Covid-19 on Educational Practice to Expedite Pedagogically Meaningful Digitization*" contributes to this effort. Based on the findings presented here – gained through a multi-method research design – we identified key issues relevant for the implementation of crisis-induced distance learning that supports both students learning and well-being: "the role of school and teaching", "recognizing and taking into account particular vulnerability among students", "set appropriate tasks", "observing students' learning behaviour", "structuring lessons" and "targeted use of digital media". Together with stakeholders from research and educational practice, we formulated guiding reflection questions for each of these issues. These are intended to support teachers and school administrators in reflective, forward-looking planning of distance learning that remains sensitive to local conditions. The reflection questions, along with additional information, are currently being compiled into a flyer, which will be iteratively revised based on expert feedback (including input gathered at the EAPRIL conference) and ultimately disseminated to schools. The flyer will be published in English, among other languages, and will be accompanied by digitally available supplementary materials that allow for continuous updates, as we are continuing to analyse our data and to examine the role of school culture in the post-pandemic context (Unger, Brauchle et al., 2025).

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THE IMPACT OF STUDENTS' SELF-REGULATION SKILLS ON LEARNING SUCCESS AND WELL-BEING DURING COVID-19

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ABSTRACT

School closures implemented to contain the COVID-19 pandemic forced students into remote learning environments that required high levels of independent work. Because research on the role of self-regulation in distance learning remains limited, this study examines how students' self-regulation skills influenced both their learning success and well-being during this period, using a multilevel mixed-methods design. First, semi-structured interviews with N = 16 Swiss teachers revealed a strong perceived positive relationship between students' self-regulation and both learning success and well-being; hypotheses were derived from these qualitative data. Second, a structural equation model based on survey data from N = 1,224 secondary students from Switzerland and Germany supported these hypotheses: Self-regulation significantly predicted learning success (β = .535, p < .001) and well-being (β = .283, p < .001). These findings underscore the critical role of self-regulation in supporting student learning and well-being under crisis conditions and beyond. Therefore, it appears important to place greater emphasis on the development of students' self-regulation skills – both in curricula planning and in teacher professional development. Specially designed learning programs may also represent a valuable approach to fostering these competencies in students. Specially developed learning programs may also be suitable for this purpose.

INTRODUCTION

School closures implemented to contain the COVID-19 pandemic represented one of the largest disruptions in the history of schooling (Betthäuser et al., 2024). In order to maintain the social function of schools (Hume et al., 2022) and to enable students to fulfil compulsory-education requirements, distance learning was introduced in

many countries. In the absence of prior experience and clear guidelines, a wide variety of distance learning formats emerged during the early stages of the pandemic (Beyer et al., 2020). The majority of these formats required a high degree of substantial independent student work; consequently, students needed strong self-regulation skills to engage successfully. Numerous studies have demonstrated that self-regulation influences both students' learning success (Brauchle & Unger, in preparation; Hadwin et al., 2022) and their well-being (Brauchle et al., 2025; Holzer et al., 2023). While the importance of self-regulation for these two central educational outcomes – learning success and well-being – has been documented (Creemers & Kyriakides, 2008), previous research has typically considered self-regulation as one factor among many, rather than as a primary explanatory variable. Furthermore, the effect of self-regulation on both outcomes has rarely been examined within a single integrated model. As a result, the relative effects on learning success and well-being, particularly during the COVID-19 pandemic, cannot yet be directly compared. In addition, most existing studies rely primarily on student or parent reports, thus reflecting only individual perspectives on the teaching process. Notably, parents are only secondarily involved in the instructional process, which may constrain the validity of their observations regarding teaching practices. The present study addresses this gap by first investigating teachers' expert perspectives on the teaching–learning process and then examining students' experiences as learners. To this end, an exploratory sequential mixed-methods approach was employed (Creswell & Cresswell, 2018) to investigate the influence of self-regulation on students' learning success and well-being during the pandemic:

Study 1: In semi-structured interviews, $N = 16$ Swiss teachers from different language regions were invited to share their observations regarding the effects of the COVID-19 pandemic on students' learning success and well-being. Based on qualitative analysis of their responses, we formulated the following hypotheses: (1) Students with stronger self-regulation achieved greater learning success during the COVID-19 pandemic. (2) Students with stronger self-regulation reported higher levels of well-being during the COVID-19 pandemic.

Study 2: We tested these hypotheses in a quantitative study using structural equation modelling with survey data from $N = 1{,}224$ students from Germany and Switzerland. This combined qualitative-quantitative approach offers a comprehensive basis for understanding how self-regulation shaped students' learning success and well-being during the COVID-19 pandemic. Following the logic of exploratory research, we first developed hypotheses qualitatively and then tested them quantitatively using an appropriate sample sizes.[4] Although the COVID-19 pandemic has largely subsided, future school closures remain a real possibility due to emerging waves of illness (Marani et al., 2021) or extreme weather events (Clarke et al., 2022), as illustrated by the floods in Spain in autumn 2025 (Jones, 2024) and the wildfires in Los Angeles in winter 2025 (Mpoke Bigg, 2025). It is therefore essential to draw practical lessons from the COVID-19 pandemic to prepare for similar future disruptions. In this context, strengthening students' capacity for independent work and systematically

[4] A similar methodological approach was used by Brauchle et al. (under review). The present study is also based on the same database.

promoting their self-regulation skills is of central importance. These competencies not only prepare students for future crises but can also enhance everyday teaching practice – since the ability to learn in a self-regulated manner is a foundational requirement for effective and sustainable learning in general (Landmann et al., 2009).

THEORETICAL AND EMPIRICAL BACKGROUND

Self-Regulated Learning

Self-regulated learning (SRL) is a central construct in educational psychology, encompassing the cognitive, motivational and emotional dimensions of the learning process (Panadero, 2017). It is understood as a cyclical, goal-oriented process that involves planning, monitoring, and evaluating one's own learning activities (Zimmerman, 2002). Key components of SRL include cognitive content processing, motivational regulation, metacognitive monitoring, socio-emotional and emotional regulation, as well as attentional control (Järvelä & Hadwin, 2024). SRL is regarded as a foundational skill for learning in modern society (OECD, 2019) as it plays a critical role not only in formal education, but also in informal and professional learning contexts (Zimmerman, 2002). Accordingly, it is considered a core competence for lifelong learning (Taranto & Buchanan, 2020).

Effect of SRL on Learning Success

Numerous studies have shown that self-regulation predicts learning success (Dent & Koenka, 2016). Cognitive learning strategies promote deeper information processing and improved memory retention (Dunlosky et al., 2013), while metacognitive skills enable more accurate self-assessment and the adaptive adjustment of learning strategies (Efklides, 2011). Motivational aspects of SRL support higher self-efficacy and sustained effort (Bandura, 1997), and behavioural components facilitate persistence and effective learning management by structuring the learning environment (Järvelä & Hadwin, 2024). During the COVID-19 pandemic, several studies also reported positive effects of self-regulation on learning success (Brauchle & Unger, in preparation; Hadwin et al., 2022).

Effect of SRL on Well-Being

Students with stronger self-regulation tend to report higher levels of well-being (Rodríguez et al., 2022). This finding aligns with eudaimonic conceptions of well-being, which emphasize goal attainment and the fulfilment of psychological needs – particularly competence – as key contributors to well-being (Ryff et al., 2021; Ryan & Deci, 2000). A general commitment to personal goals further enhances subjective well-being (Garcia et al., 2015), while better self-regulation is associated with reduced academic stress, which in turn further promotes well-being (García-Ros et al., 2023). However, if learning tasks are perceived as threatening to self-esteem, students may use protective strategies such as task avoidance or emotional distancing (Boerkaerts, 2011). While these strategies may preserve well-being in short term, they often inhibit learning over time (Boerkaerts, 2011). Thus, difficulties in SRL

can produce complex effects: temporarily supporting well-being while undermining academic progress. These potentially opposing mechanisms highlight the importance of examining the extent to which SRL influenced well-being during the COVID-19 pandemic, a period in which learning was largely self-directed and independent (Tlili et al., 2022). Here, prior studies report that students with stronger self-regulation experienced higher levels of well-being (Brauchle et al., 2025; Holzer et al., 2023).

Conclusion

Although several studies suggest that SRL is associated with both learning success and well-being, there remains a lack of research that explicitly addresses self-regulation as a central influencing factor rather than as one predictor among others. Furthermore, there is a lack of research that enables a direct comparison of the effects of self-regulation on students' learning success and well-being from the perspective of those directly involved in teaching – particularly in the context of the COVID-19 pandemic. Addressing this gap could deepen our understanding of how crisis-related changes to educational contexts have differentially affected students' cognitive and emotional outcomes.

STUDY 1: QUALITATIVE APPROACH

Research Interest and Research Questions

In the preliminary qualitative study, teachers' perspectives were examined to explore how students' self-regulation influenced both learning success and well-being during the COVID-19-related school closures. The aim was to obtain an initial overview of the field and generate hypotheses for further investigation. The following research questions guided the analysis:

RQ1: From teachers' perspectives, how did students' self-regulation affect their learning success during COVID-related school closures?
RQ2: From teachers' perspectives, how did students' self-regulation affect their well-being during COVID-related school closures?

Methodological Approach

Sample

To address the research questions, semi-structured interviews were conducted with $N = 16$ teachers from different language regions of Switzerland. Details on the sample composition are presented in Table 1.

Table 1. *Sample Composition of Interviewed Teachers*

Variable	Category	*n*	%
Gender	Female	11	68.8
	Male	5	31.3
Teaching region (Switzerland)	German-speaking	11	68.8
	French-speaking	2	12.5
	Italian-speaking	3	18.8
School level taught	Primary school	4	25.0
	Lower secondary school	6	37.5
	Upper secondary school	6	37.5

Interview Guide

The interviews were conducted using a semi-structured interview guide. The guide was developed inductively based on relevant thematic topics, evaluated through a multi-stage expert validation process, and tested in a pilot study. The final version covered five main topics: *lesson planning during the school closures*, *digital learning media, student learning success*, *students in quarantine*, and *student well-being*. Each topic comprised two to four questions, with optional follow-up prompts used as needed.

Data Collection and Analyses

The interviews were conducted by trained interviewers either in person ($n = 3$) or via video conferencing ($n = 13$) between September 2024 and January 2025. To help interviewees recall the pandemic period, the interview started with a visual stimulus: a timeline illustration showing key phases of the COVID-19 pandemic. The transcription of the interviews was conducted using the AI transcription program noScribe (Dröge, 2023), followed by a comprehensive manual review and correction process to ensure accuracy.

The data was analysed using content-structuring qualitative content analysis according to Kuckartz and Rädiker (2024), supported by the software MAXQDA (MAXQDA, 1989–2024). The initial coding frame included two deductively defined main categories: “effect of self-regulation on learning success” and “effect of self-regulation on well-being.” These categories were applied consistently across all interviews. The transcripts were independently coded by two trained coders. Coding discrepancies were resolved through a consensus discussion involving the project team (Richards & Hemphill, 2018). Each meaningful teacher statement relevant to the research focus was treated as a coding unit. The number of occurrences per code is reported following Kuckartz’s methodology.

Results

Effect of Self-Regulation on Learning Success (RQ1)

The teachers referred $n = 25$ times to a connection between higher self-regulation and better learning success (e.g. Brj06: "*The students who are naturally organized, punctual, and so on, not only had no difficulty with this, but were even at an advantage.*"[5]). Conversely, $n = 8$ teachers mentions indicated that lower self-regulation was associated with lower learning success (e.g. Brj06: "*The students who are a little more chaotic, clumsy, and less independent have suffered considerably [in terms of learning success].*").

Effect of Self-Regulation on Well-Being (RQ2)

Teachers mentioned $n = 9$ times that higher self-regulation was associated with higher well-being (e.g. Brj10: "*The [students with high self-regulation] loved that they could work independently and submit their assignments.*"). Conversely, they mentioned $n = 3$ times that lower self-regulation was associated with reduced well-being (e.g. Brj07: "*Children who really hadn't done anything at all. I don't think they were doing very well.*").

Discussion of Study 1 and Derivation of Hypotheses

The teachers indicated that higher self-regulation among students contributed to both greater learning success and enhanced well-being. These results are in line with previous research examining the impact of self-regulation on learning success and well-being from student perspective (e.g. Brauchle et al., 2025; Hadwin et al., 2022). Notably, the interviewed teachers referred more frequently to effects on learning success than to effects on well-being. Positive effects of higher self-regulation were also mentioned more often than negative effects of lower self-regulation.

Based on these qualitative findings, the following hypotheses were formulated for subsequent quantitative testing:

H1: Students' self-regulation skills during the COVID-19 pandemic positively influenced their learning success.
H2: Students' self-regulation skills during the COVID-19 pandemic positively influenced their well-being.

STUDY 2: QUANTITATIVE APPROACH

Research Questions

To test the hypotheses derived from Study 1, we examined the following research questions in the quantitative study:

RQ3: To what extent did students' self-regulation skills influence their learning success during the COVID-19 pandemic?

[5] As the interviews were conducted either in German or French, the quotes were translated into English.

RQ4: To what extent did students' self-regulation skills influence their well-being during the COVID-19 pandemic?

Methodological Approach

Sample

We conducted a secondary analysis of the student questionnaire *My Corona Diary*, in which students reported on their experiences during distance learning. All questions explicitly referred either to the period of school closures or, where applicable, to individual quarantine periods during the COVID-19 pandemic. The survey was administered in German using the web application SoSci-Survey (Leiner, 2022). The survey link was distributed to students in Germany, Austria, and Switzerland via personal contacts, mailing lists, and the mailing list of a commercial platform. Data collection took place between April 5 and July 22, 2022. As only three students from Austria participated, all analyses were restricted to students from Germany and Switzerland. The final sample consisted of N = 1,224 secondary school students aged 10 to 20 years (M = 16.1; SD = 2.0). Table 1 provides an overview of the sample characteristics.

Table 1. *Sample Composition of the Quantitative Study*

Subgroups	Switzerland		Germany		Total	
	n	%	*n*	%	*n*	%
Gender						
Female	89	52.7	719	68.2	808	66.0
First language						
German	134	79.3	776	73.6	909	74.3
Other than German	35	20.7	279	26.4	315	25.7
Survey group[†]						
Cohort 1*	68	40.2	477	45.2	545	44.5
Cohort 2**	91	53.8	418	39.6	509	41.6
N total	169	13.8	1,055	86.2	1,224	100

*Students who were in quarantine either at the time of data collection or within three months preceding data collection. **Students who were not in quarantine at the time of data collection and had not been in quarantine during the preceding three months. [†]Due to missing data, 170 students (13.9%) could not be assigned to a survey group.

Survey Instrument

Students' self-regulation skills were assessed using nine items (e.g. "I set learning goals for myself") rated on a 4-point scale (1 = not at all to 4 = exactly). The scale is based on Zimmerman's (2002) conceptualization of self-regulation and was adapted by Toering et al. (2012). The internal consistency in the present study was α = .827.

Learning success was operationalized using the following variables: *(1) Grades in mathematics and German:* Students self-reported their current grades in both subjects. As the German and Swiss grading systems differ, the German students'

grades were subsequently converted into the Swiss grading system (6 = *best*; 1 = *worst*; 0.5-grade increments). Although grades are influenced by teacher judgments and classroom contexts, they are well suited to assess and predict learning success due to their multidimensional nature (Thorsen & Cliffordson, 2012). In contrast to standardized tests, grades also capture aspects such as students' interest and engagement (Klapp Lekholm & Cliffordson, 2009). *(2) Self-assessed learning success:* Students rated their perceived learning success in distance learning compared to regular in-person lessons on a 5-point scale (1 = *not good at all* to 5 = *very good*).

Well-being was assessed according to Diener's (1994) definition and the associated bottom-up theory (Diener & Ryan, 2009), using the following measures: *(1) Perceived stress:* Students completed a subscale of the "*Stress in Distance Learning Scale*" (Rogge & Seifert, 2023), consisting of five items (e.g. "*The demands of school are very stressful for me*"), rated on a 7-point scale (1 = *never* to 7 = *always*). Internal consistency was α = .900. *(2) Fear of the consequences of the COVID-19 pandemic:* This was measured with four items from the "*Epidemiebezogene Dark Future Scale für Kinder (eDFS-K)*" (Voltmer & von Salisch, 2021), including items such as "*Are you worried that the coronavirus will prevent you from pursuing your hobbies, graduating from school or finding your dream job in the future?*". Responses were given on a 4-point scale (1 = *never* to 4 = *often*). Internal consistency was α = .781. *(3) General life satisfaction:* General life satisfaction was assessed using the single item "*Overall, how satisfied are you with your life right now?*", adapted from the "Kurzskala zur Erfassung der Allgemeinen Lebenszufriedenheit (L-1)" (Beierlein et al., 2015), and rated on an 11-point scale (1 = *not at all satisfied* to 11 = *completely satisfied*).

Although the perceived stress and fear measures employed ordinal response formats, the items were treated as continuous variables in accordance with Robitzsch (2020) and the recommendations of the respective scale authors.

Analysis

To answer the research questions, we specified a structural equation model (SEM) in Mplus (Muthén & Muthén, 1998–2017), that simultaneously estimated the effects of self-regulation on learning success (RQ3) and well-being (RQ4). Both learning success and well-being were modelled as latent variables, as described above. Because the scales for perceived stress and fear of the consequences of COVID-19 measure negative aspects of student well-being, these variables were reverse-coded so that the latent well-being variable would represent students' positive well-being. All path coefficients were standardized. Model fit was evaluated using the Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR).

Since students were allowed to skip individual items, a total of 23.5% of all values were missing in the dataset. Further analysis revealed that younger students were more likely to leave items unanswered and that items placed later in the survey had higher rates of non-response. These patterns indicated that the data were not "missing

completely at random" (MCAR; Enders, 2023). To minimize bias due to systematic missingness and to retain the largest possible sample size, model-based multiple imputation was carried out using Blimp (Enders et al., 2022), a robust method for handling missingness in structural equation modelling.

Prior to the main analysis, we assessed the psychometric properties of all scales through unidimensional confirmatory factor analyses (CFAs). The results indicated acceptable to good model fit ($.938 \leq CFI \leq 1.000$; $.000 \leq RMSEA \leq .126$[6]; $.005 \leq SRMR \leq .054$) in line with Hu and Bentler (1999). We also tested for measurement invariance of the constructs "perceived stress," "fear of the consequences of the COVID-19 pandemic," and "self-regulation" across gender, age, country of education, and first language, using the step-up approach (Schwab & Helm, 2015). According to the criteria proposed by Chen (2007; $\Delta CFI \leq 0.020$; $\Delta RMSEA \leq 0.015$), the "fear of the consequences of COVID-19" scale showed metric invariance for gender and country of schooling. All other constructs exhibited strict measurement invariance.

Results

Figure 1 shows the structural equation model. The model demonstrated very good fit (CFI = .965, RMSEA = .030, SRMR = .044; Hu & Bentler, 1999).

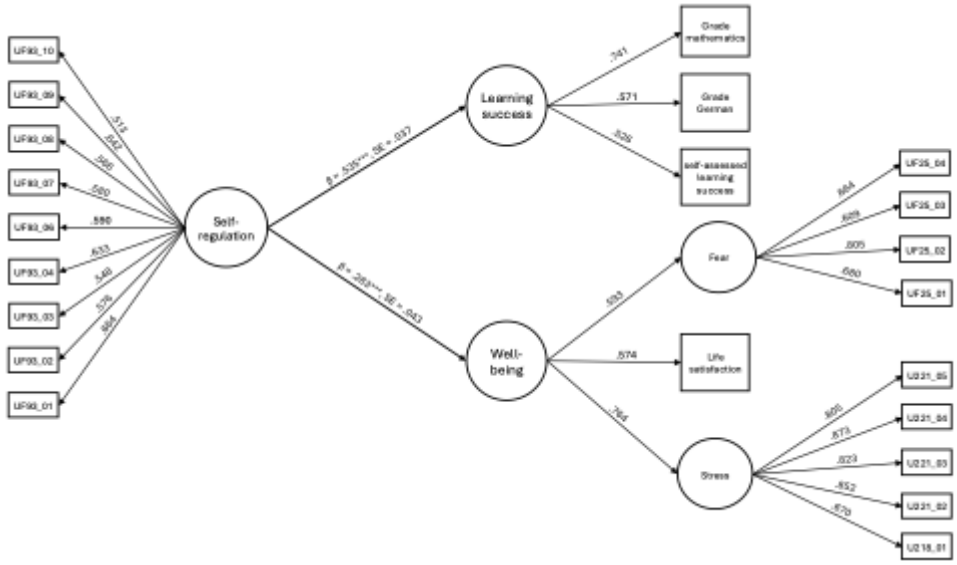

Figure 1. *Structural Equation Model Regarding the Effect of Self-Regulation on Learning Success and Well-Being*

[6] The relatively high RMSEA value for the scale "fear of the consequences of the COVID-19 pandemic" (.126) is in line with the value reported by the authors of the scale (Voltmer & von Salisch, 2021). To ensure comparability with the published scale, the scale was retained without modification.

Note. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

For RQ3, we found a significant positive effect of students' self-regulation skills on learning success (β = .535, SE = .037, $p < .001$). For RQ4, we found a significant positive effect of students' self-regulation skills on well-being (β = .283, SE = .043, $p < .001$).

Discussion Study 2

The quantitative study tested the hypotheses derived from Study 1 using structural equation modelling. Regarding RQ3, we found a strong positive effect of students' self-regulation on learning success during the COVID-19 pandemic, thereby confirming Hypothesis 1. For RQ4, the analysis revealed a small to moderate positive effect of self-regulation on students' well-being, providing support for Hypothesis 2.

GENERAL DISCUSSION

Teaching during the COVID-19 pandemic was largely characterized by students' independent work (Helm et al., 2021), which suggests that self-regulation was required for successful learning during this period (Tlili et al., 2022). Findings of reduced learning success (e.g. Wisenöcker et al., 2025) and declines in student well-being (e.g. Essler et al., 2024) indicate that many students faced substantial challenges.

In this study, we employed a sequential exploratory mixed-methods approach to investigate the influence of self-regulation on both learning success and well-being. In the qualitative study, teachers reported that students with higher levels of self-regulation experienced greater learning success and well-being during the pandemic, while students with lower self-regulation were more likely to struggle in both areas. The quantitative analysis confirmed these perceptions: structural equation modelling revealed significant positive effects of self-regulation on both outcomes in one single model. These findings underscore the importance of self-regulation for both student learning success and well-being. They are in line with previous studies demonstrating the positive impact of self-regulation on learning success during the pandemic (Brauchle & Unger, in preparation; Hadwin et al., 2022) and under regular conditions (Dent & Koenka, 2016), as well as on student well-being during (Brauchle et al., 2025; Holzer et al., 2023) and beyond the pandemic (Rodríguez et al., 2022). The increased autonomy and independent work as well as reduced teacher and peer interaction during the pandemic likely amplified the influence of self-regulation.

In the qualitative data, teachers more frequently mentioned the influence of self-regulation on learning success than on well-being. This pattern is mirrored in the quantitative results, which revealed a strong effect on learning success and a small to moderate effect on well-being. These findings suggest that self-regulation had a stronger impact on learning success than on well-being. This is plausible given that well-being is a multidimensional construct influenced by a wide range of external

and internal factors (Diener, 1994), whereas learning success during distance learning depended more heavily on students' individual regulation strategies. Nevertheless, it is also important to consider the effects of self-regulation on well-being, particularly in efforts to support students' holistic development. Research demonstrating a positive correlation between learning success and well-being (Brauchle et al., under review) further underscores the importance of addressing both outcomes in schooling – not only under crisis conditions, but also in everyday school contexts. In this regard, self-regulation emerges as a shared predictor of both outcomes, further highlighting the importance of supporting students' self-regulation skills.

Accordingly, fostering students' self-regulation skills and thus '*learning how to learn*' should be integrated as an integral part of the curriculum, both to prepare students for future crisis situations and to equip them with essential competencies for their professional and personal lives (OECD, 2019; Taranto & Buchanan, 2020). For that, it is important to explicitly demonstrate the different steps of self-regulated learning to students (Dignath & Büttner, 2008) and to focus particularly on their ability to reflect (Veenman et al., 2006). To practice SRL, it may further be beneficial to regularly incorporate project-based work into lessons (Stefanou et al., 2023) and to use specially developed training programs to foster students' self-regulation skills (Dignath & Büttner, 2008).

Limitations

The study has several limitations that must be considered when interpreting the results. For the qualitative study, self-selection bias among participating teachers is likely. It is plausible that those with a greater interest in the topic of distance learning were more inclined to participate. In addition, recall bias may have influenced teachers' responses due to the time elapsed since the pandemic (Coughlin, 1990).

The quantitative survey of students also has several limitations. Since the survey was administered online, students with unreliable internet access or limited digital skills – groups that were particularly disadvantaged during the pandemic (Unger et al., 2020) – may be underrepresented in the sample. The student data were self-reported and cannot be externally verified. This limitation is particularly relevant for the self-reported grades in mathematics and German. However, descriptive analyses did not reveal any implausible or extreme values, which suggests acceptable data quality. Furthermore, the operationalization of the main outcome variables represents a simplification of the underlying constructs. Learning success was assessed through grades and self-assessed learning success, and well-being through perceived stress, fear of the long-term consequences of the pandemic, and life satisfaction. While these indicators capture relevant dimensions, they do not fully reflect the multifaceted nature of either construct. Nevertheless, we sought to model both outcomes as comprehensively and reliably as possible within the constraints of an online student survey.

Conclusion

Overall, the findings highlight the central role of self-regulation skills in supporting both student well-being and learning success – not only under crisis conditions, such as those experienced during the COVID-19 pandemic, but also during regular instruction. The documented negative effects on learning success and well-being during the COVID-19 pandemic suggest that many students face challenges in self-regulated learning, particularly when external structures and support systems are reduced. These results highlight the urgent need to systematically foster self-regulation skills in school settings – both to better prepare students for future disruptions in the education system and to equip them with essential competencies for lifelong learning and personal development.

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SOCIAL FEEDBACK AND SIMULATED AUDIENCES: A PROOF-OF-CONCEPT FOR PERSONA-BASED LLM FEEDBACK IN WRITING INSTRUCTION

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ABSTRACT

Writing is fundamentally a social act. This article argues that the development of writing competence requires social feedback—reader responses that reveal how a text is understood, experienced, and interpreted by an external audience. We address three key challenges for implementing such feedback in classroom settings: (1) the logistical difficulties of establishing authentic classroom writing communities; (2) the lack of theoretical models defining the specific feedback literacy skills needed to interpret subjective reader reactions; and (3) the underutilization of the persona-simulation capabilities of Large Language Models (LLMs). To address these gaps, we propose a theoretical framework of the competencies required to process social feedback, grounded in the Writer(s)-Within-Community model. We further present yourMoment, a proof-of-concept tool for providing simulated social feedback on student blogging platforms using persona-based LLM responses. We conclude that this form of "artificial sociality" offers a scalable pathway to foster students' social feedback literacy and re-establish the communicative function of writing in classroom contexts.

INTRODUCTION

Writing is a key skill for participation in society (Unger, 2024)—particularly in the digital age (Smit et al., 2024). While professional and personal writing is inherently communicative, e.g., intended to inform, persuade, or entertain an audience (Philipp, 2014), school-based writing is often reduced to a demonstration of proficiency for a single reader: the teacher. This discrepancy can create a "fake audience" phenomenon (Sperling, 1993), in which students prioritize compliance with normative standards over communicative effectiveness. As a result, learners often struggle to anticipate reader reactions or to revise their texts based on how the texts

are actually perceived. The challenge for educators is to create "writing communities" (Graham, 2018) within the constraints of the classroom. To address these challenges, student blogging platforms like *myMoment* have long established authentic digital writing communities where social peer feedback is the central driver for writing development (Sturm et al., 2023). Although peer feedback has shown pedagogical value (Sturm & Weder, 2016), it is often limited by students' developing literacy skills, social dynamics, and the resource constraints typical of everyday school settings (Wu & Schunn, 2021). Here, recent advances in generative Artificial Intelligence (AI), specifically Large Language Models (LLMs), offer a novel, complementary opportunity. Unlike traditional educational technologies that focus mostly on evaluative feedback like automated scoring or grammar correction (Shi & Aryadoust, 2024), LLMs can simulate personas (Park et al., 2024; Wang et al., 2024) reacting as readers to student texts.

This article addresses three critical deficits at the intersection of writing theory and educational technology: (1) the logistical conflict between the theoretical necessity of "writing communities" and the practical constraints of the classroom; (2) the lack of theoretical models describing specific feedback literacy skills required to decode social feedback; and (3) the underutilization of LLMs, which are currently predominantly deployed as "corrective editors" or "ghostwriters" rather than "simulated audiences"—a function that would occupy a role between what Steinhoff and Lehnen (2025) classify as a "writing partner" and a "writing tutor".

To bridge these gaps, we proceed as follows: First, we outline the theoretical underpinnings of social feedback within the Writer(s)-Within-Community (WWC) model, proposing a preliminary competency framework for processing reader reactions. Subsequently, we present *yourMoment*, a proof-of-concept system integrated within the Swiss student blogging platform *myMoment*, designed to operationalize these concepts by generating persona-based feedback. Finally, we discuss the implications of "artificial sociality" in writing communities.

THEORETICAL BACKGROUND

To understand how LLMs can effectively support students' writing skills, we must look beyond their technological capabilities and engage with theories of writing itself as well as writing instruction.

Some theoretical frameworks argue that writing competence does not develop in a vacuum but through interaction with a community that responds to written texts (Graham & Perin, 2007). In this section, we first analyse the communicative function of texts to then contrast the roles of evaluative and social feedback in this context. After that we focus on the students' perspective and use Graham's Writer(s)-Within-Community model to map the cognitive processes required to translate external social feedback into internal revision strategies. Furthermore, we identify the specific components of feedback literacy required to navigate this social exchange.

The Communicative Function of Texts

The fundamental conceptualization of the communicative function of texts rests on the premise that writing is a social activity (Graham, 2018). Unlike earlier cognitive-process models that focused on mental operations (Hayes & Flower, 1980), a social perspective holds that writing is an act of conveying ideas, questions, and experiences to others (Block & Strachan, 2019). This social component is also increasingly represented in newer theoretical models of writing (e.g., Hayes, 2012).

The communicative function implies that writing serves one or more purposes (Graham, 2018). These range from maintaining social communication to persuading others or creating imaginary worlds (Graham, 2018). In educational settings, this communicative objective might clash with traditional institutional goals when writing in the classroom is reduced to demonstrating competence (Block & Strachan, 2019). Thus, modern instructional theories for writing call for moving beyond writing solely for the assessing teacher (the internal audience) towards writing for an external audience that engages with the text for its communicative objective (Block & Strachan, 2019).

The awareness of the intended audience is identified as a critical consideration for the writer (Block & Strachan, 2019). Drawing on Bakhtin's theory of addressivity, writing is inherently dialogic. It responds to prior utterances and anticipates subsequent reactions from recipients (Myklebust & Høisæter, 2018). For a text to be communicatively effective, the writer must make deliberate decisions guided by audience awareness (Block & Strachan, 2019; Graham, 2018) and their capability of perspective-taking (Aitken et al., 2025).

The process of achieving communicative goals can often entail iterative revision or reconceptualization (Graham, 2018) of texts. Feedback is crucial here, providing an external perspective to diagnose mismatches between intended meaning and reader perception (Bouwer et al., 2024). Accordingly, students learn how effective their text is by evaluating audience responses and then making targeted revisions that improve the text's communicative effectiveness (Bouwer et al., 2024; Midgette et al., 2008).

Social Feedback vs. Evaluative Feedback

Feedback plays a central role in (writing) instruction (Wisniewski et al., 2020); however, its implementation often varies markedly in scope and focus. This section examines two distinct feedback paradigms that influences students' motivation and their conceptualization of writing: a teacher-centric evaluative model and a community-oriented social model.

In educational settings evaluative feedback predominates, in which the teacher serves as the primary assessor of text quality. Such feedback is typically normative, measuring a text against standards or rubrics establishing a vertical hierarchy between expert and novice. Although sociocognitive theory frames writing as an inherently social and communicative act (Sperling, 1993), the evaluative model often contrasts with this view by positioning writing as a performance for what Sperling (1993) terms a "fake audience". In this instructional context, the student's communicative objective may shift from conveying meaning to demonstrating

competence for assessment purposes (Block & Strachan, 2019). Furthermore, it has been shown that this form of writing, when done exclusively for the teacher, can undermine students' motivation to write (Chen & Brown, 2012).

In contrast, social feedback is grounded in the sociocultural theories of writing as a social practice (Graham, 2018; Sperling, 1993). This paradigm conceptualizes feedback as a meaning-oriented response from a community of readers. Social feedback is primarily descriptive, articulating how a text is understood and interpreted by a reader, and reactive, comprising inquiries, emotional responses, or personal connections. This exchange occurs within a horizontal social structure that positions the writer as a participant in a "writing community", fostering dialogue rather than unidirectional exchanges with an authority figure (Bakan, 2017). Empirical research indicates that moving from an evaluative to a social feedback model also yields concrete pedagogical benefits. By engaging with responses from external readers, learners develop perspective-taking skills and overall audience awareness (Block & Strachan, 2019), which, in turn, contributes to effective communication and improved text quality (Aitken et al., 2025). Furthermore, writing for an external audience has been shown to increase student motivation, effort, and engagement (Chen & Brown, 2012; McGrail & Davis, 2011; Weider, 2012).

Despite the documented benefits, systematic implementation of social feedback in schools remains infrequent (see e.g. Block & Strachan, 2019, for audience awareness; Loretto et al., 2016, for peer feedback or Bouwer et al., 2024 for dialogic talk). Logistical and structural constraints tend to reinforce the evaluative, teacher-as-audience model as standard practice (Wu & Schunn, 2021). This results in a persistent gap between the theoretical ideal of a writing community and the realities of classroom instruction.

The Writer(s)-Within-Community Model

The theoretical bridge between external social interactions and the writer's internal cognition is well captured by Graham's (2018; 2023) Writer(s)-Within-Community (WWC) Model. The WWC model explicitly integrates cognitive models of writing with sociocultural perspectives (Graham, 2018, 2023). This integration posits that writing is a social activity driven by communicative purpose, yet both constrained and enabled by the individual writer's capabilities (Graham, 2018, 2023).

Within the WWC model, social feedback is a critical component of the overarching writing community activities (Graham, 2018). The writing community includes collaborators, readers, teachers, and peers (Graham, 2018) and establishes shared goals, norms, expectations, and intentions that fundamentally shape the writing activity (Graham, 2018). Crucially, an external audience provides the perspective necessary for the writer to identify potential mismatches between their intended meaning and communicative goals, and how these are actually perceived by readers (Bouwer et al., 2024). The divergence between the intended and the perceived communicative objective can create the need for revision. In this context, revision is legitimized not merely as error correction, but as a negotiation aimed at resolving the communicative mismatch made visible by social feedback.

The WWC model articulates revision as a continuous, bidirectional interplay between the external community and the writer's internal cognitive architecture (Graham, 2018; 2023). Social feedback as a stimulus for revision first challenges the writer's current perception of the text's communicative effectiveness. The translation of this social stimulus into a revision mandate occurs within the executive control system, where the feedback signals a gap between intended and achieved communicative function. This can trigger a cascade of cognitive processes. The writer plans new strategies to address the gap (e.g., adding evidence or further information), monitor whether these plans will satisfy the reader's objection, and decides whether to modify the text or dismiss the feedback (Graham, 2018). If executive control accepts the feedback, the process proceeds to reconceptualization (Graham, 2018), during which the text is altered to align with audience demands, thereby transforming the writer's understanding of the original task. Crucially, this entire process is influenced by the writer's competence and literacy (Graham, 2018).

The Role of Feedback Literacy in the Context of Social Feedback

The processing of external social feedback is challenging, especially for novice writers with low feedback literacy. For revision to occur, external feedback must be converted into internal feedback (Carless, 2022; Carless & Boud, 2018). While students' feedback literacy, defined as such capacity to process external feedback (Schluer et al., 2023), is well-established in the literature, there remains a lack of comprehensive competency models tailored to processing social feedback in classroom-based digital writing communities.

Processing social feedback differs from processing standard teacher evaluations, as it is often unstructured, subjective and emotive. Few theoretical or instructional concepts currently exist that detail how social feedback processing is understood in detail. Consequently, the competencies outlined below constitute a preliminary theoretical sketch extrapolating from general feedback literacy frameworks. Within the WWC model, we propose characterizing this terrain across three interconnected phases: processing and decoding, evaluating and judging, and action and application.

Processing and Decoding Competencies

This phase involves the receptive capacity to engage with external input and integrate it into the student's cognitive resources (Meyer et al., 2025). A key competency is understanding the nature and intent of the feedback source (Carless, 2022). Students should analyse the feedback "ecosystem" by situating the feedback within the norms and purposes of the writing community (Graham, 2018). Such awareness enables judgments about source trustworthiness, the relevance of comments to communal goals, and alignment between the feedback and the text's communicative function (Kerman et al., 2024).

Students also need the analytical ability to decompose complex feedback into actionable components. This competence aligns with using coding templates (e.g., decode praise, question, misunderstanding or critique) to categorize comments

structurally (Nelson & Schunn, 2009). Doing so helps distinguish high-order concerns (HOCs; e.g. content, clarity, structure, or argumentation) from lower-order concerns (LOCs; e.g. grammar, spelling, punctuation; Bouwer et al., 2024). This differentiation is valuable because HOC-focused feedback generally yields more meaningful revisions (Bouwer et al., 2024).

Evaluating and Judging Competencies

This phase engages the student's executive control, encompassing the metacognitive capabilities needed to process information, weigh its merit, manage emotional responses, and decide on action (Graham, 2018; Meyer et al., 2025). The student must exercise evaluative judgment about the quality of feedback received (Carless & Boud, 2018). This includes distinguishing isolated comments from the dominant pattern of responses to avoid overemphasizing anomalous feedback (Mulder et al., 2014). It also entails comparing writing intent with reader responses (Magnifico, 2010), assessing whether the feedback aligns with the student's original communicative objective or anticipated audience reaction (Midgette et al., 2008), and reflecting on the initial conceptualization of the writing task (Graham, 2018).

Students also need resilience to maintain emotional equilibrium and overcome defensive or demotivating reactions often triggered by critical or contradictory feedback (Carless & Boud, 2018). Managing affect is essential for sustained engagement through the processing and action phases (Meyer et al., 2025). Finally, the student must decide whether to accept, modify, rebut, or reject the feedback (Graham, 2018; Loretto et al., 2016) based on informed judgment rather than social pressure. This explicit decision process ensures that the student remains the owner of the text and the arbiter of its revision (Graham, 2018).

Action and Application Competencies

This phase shifts to the practical execution of the revision mandate, converting accepted feedback into tangible textual changes (Price et al., 2011). Students must be able to reflect and generate clear revision plans (Graham, 2018). This involves formulating concrete intentions and selecting the appropriate strategies or "schemas" to address the problems identified by the feedback (Graham, 2018). It requires mapping abstract comments (e.g., "I was confused when reading…" or "I was not convinced by your argument") onto specific reconceptualization acts (e.g., adding evidence, rearranging the introduction; reformulate the claim; Graham, 2018; Midgette et al., 2008). The efficiency and scope of revisions often improve when students regularly practice the analytical skills involved in providing feedback to others (Philippakos, 2017).

Effective application relies also on perspective-taking (Aitken et al., 2025) and audience awareness (Block & Strachan, 2019; Midgette et al., 2008). Students must adjust to the perceived needs of the audience and judge the effect of proposed changes. Strategies, such as intentionally rereading the draft through the audience's eyes help ensure that revisions enhance communicative effectiveness rather than merely correcting surface errors (Holliway & McCutchen, 2004).

In sum, although the components of feedback literacy are broadly delineated, the specific mechanisms by which students successfully utilize social feedback remain largely theoretical. This lack highlights the need for empirical research to elicit and support these complex processes. Since the creation of "writing communities" with external audiences is challenging within classroom constraints we propose an LLM-driven approach to provide social feedback from a simulated external audience.

The Potentials of LLM Technology in the Context of Social Feedback

To bridge the gap between the theoretical necessity of social feedback and the logistical constraints of the classroom, we propose leveraging the specific affordances of generative AI. Whereas early Automated Writing Evaluation (AWE) systems focused predominantly on LOCs, Large Language Models (LLMs) offer the ability to simulate human-like subjectivity and persona-based reactions, which could contribute to the HOC focus.

Historically, automated feedback has been heavily skewed toward the evaluative paradigm. A systematic review by Shi and Aryadoust (2024) found that only 22.4% of automated writing feedback studies addressed HOCs, prioritizing primarily form and rule adherence. Such limitation arises because traditional algorithms are deterministic and designed to compare text against a fixed standard of correctness. In contrast, LLMs function probabilistically. This architecture, while occasionally prone to factual "hallucination", is uniquely suited to persona adoption and role prompting. Research in computational social science demonstrates that LLMs can simulate specific human perspectives with notable fidelity. Park et al. (2024) showed that profile-conditioned LLM agents replicated human responses with 85.0% accuracy. Similarly, Wang et al. (2024) found that role-playing agents achieved high alignment with human-perceived personalities of simulated characters.

We argue that the probabilistic nature of LLMs is not a flaw in this context but a feature. It allows an LLM-based AWE system to prioritize social feedback. By prompting an LLM to adopt a specific persona (e.g., a "quickly bored peer student" reading a story or a "sceptical school principal" reading a petition) one can generate feedback that mirrors the variability and subjectivity of human interaction (Argyle et al., 2023; Park et al., 2024; Wang et al., 2024).

Emerging research suggests that LLM agents may lower the affective barrier to feedback processing and revision. Henderson et al. (2025) found that although students trust teacher feedback more, LLM-generated feedback did induce fewer negative feelings and felt less risky. This creates a low stakes environment in which students can experiment with e.g. rhetorical strategies and communicative elements without evaluation anxiety (Zhan & Yan, 2025).

An LLM-based AWE system does not replace the teacher but acts as a communicative partner (Levine et al., 2025), taking an intermediary role between a "writing partner" and a "writing tutor" (Steinhoff & Lehnen, 2025). By receiving persona-based reactions students are forced to confront the communicative effect of

their writing. This can activate the revision competencies outlined in our framework: decoding the (simulated) reader's confusion, inferring its structural cause, and executing a revision plan to clarify meaning.

Conclusion of the Theoretical Framework and Research Gap

The theoretical discussion presented above reveals a distinct convergence of pedagogical need and technological capability, yet questions and challenges remain in both theory and practice. First, although the WWC model posits that social feedback is a primary driver of revision competence (Graham, 2018), current practice is constrained by the logistics of providing every student with a diverse, real-time audience. Second, despite extensive research on feedback literacy, there is a lack of specific competency models detailing how students decode and utilize social feedback. We have hypothesized requisite competencies, but instructional frameworks to foster or scaffold them are scarce. Third, while LLMs demonstrate the technical capacity to simulate diverse personas (Argyle et al., 2023; Park et al., 2024; Wang et al., 2024), most educational LLM applications remain rooted in the evaluative feedback tradition, emphasizing competence demonstration over meaning-oriented communicative effectiveness (Shi & Aryadoust, 2024).

To address the interconnected gaps described above, the following section introduces *yourMoment*, a proof-of-concept software implementation developed to operationalize these theoretical concepts.

MATERIALS AND METHODS

We describe the system architecture of *yourMoment* and present preliminary prompt engineering guidelines designed to translate generic LLM capabilities into a structured pedagogical tool for generating social feedback. This software project was developed within the *DEEP myMoment* research and development project, itself part of the *Digital Education for Equity in Primary Schools (DEEP) research consortium,* which explores how digital transformation can promote equitable and effective learning in Swiss primary education. Development was led by St.Gallen University of Teacher Education.

System Architecture of the yourMoment Platform

The *yourMoment* platform is a web-based application that orchestrates interaction between a web-based digital writing platform—in our case currently the Swiss student blogging platform *myMoment*—and external LLM providers. The system uses a modular architecture separating an API layer, business logic, and asynchronous background processing to ensure scalability and reliability during classroom usage.

At present, yourMoment is conceptually and technically rooted in myMoment (Sturm et al., 2023): Originally launched in 2005 by the FHNW School of Education, it was developed to enable open, community-based writing in a safe online environment. Over time, it has evolved through collaborations with the "Zentrum

Lesen" and imedias (FHNW School of Education), aiming to strengthen students' writing skills, media literacy, and engagement through peer feedback and collaborative writing activities. In the future we plan to support other blogging platforms (e.g., WordPress).

To operationalize the theoretical concept of a simulated external audience, the system utilizes a flexible prompt template module that allows researchers and teachers to define a persona within the prompt text itself, leveraging the LLM's capacity for role prompting.

Concretely, *yourMoment* manages reusable templates containing specific instructions for the LLM (e.g., "You are a quickly bored peer student giving feedback on a story" or "You are a sceptical school principal answering a student's letter"). These templates are used to generate dynamic prompts. At runtime, the system injects context-specific variables into the prompt using standardized placeholders (e.g., {article_content}, {article_title} and {article_author}). This design keeps the persona consistent across outputs while generating feedback tailored to the individual student's text, its title and the username of the student on the blogging platform.

The platform operationalizes the social feedback generation loop through a multiple-step workflow:

1. *Authentication and Configuration:* The teacher registers on *yourMoment* and configures the working environment by adding encrypted credentials for an account on the student blogging platform and preferred LLM provider API keys.
2. *Audience Definition:* The user creates or selects a prompt template to define the pedagogical intent by specifying how the "audience" should act. The user can choose to use predefined prompt templates tailored to specific writing tasks (e.g., a persuasive letter to a school principal) or create new prompts.
3. *Process Orchestration:* The user initiates a monitoring process by binding a specific account on the student blogging platform to a prompt template and defines filters (e.g., classes, text categories or keywords). The given account is used to read students texts and post the generated comments on the platform.
4. *Discovery and Generation:* When the monitoring process starts, a parallelized pipeline runs. A discovery process scrapes the student blogging platform for new texts matching the criteria. A preparation process fetches full text content. A generation process sends the combined prompt (template and inserted context-specific variables) to the LLM provider to generate the social feedback.
5. *Validation and Posting:* The system validates the generated response and adds a mandatory disclosure statement. If validation succeeds, the posting task publishes the comment directly to the student's text on the blogging platform.
6. *Monitoring and Review:* Teachers monitor the activity via a dashboard that tracks articles discovered, feedback generated, and any operational errors.

The design of the *yourMoment* architecture and its integration with student blogging platforms therefore adhere to the theoretical requirements of a writing classroom that treats writing as a social activity by providing an on-demand external audience and social feedback. It establishes a foundation for creating learning resources that foster

social feedback literacy and revision competence oriented toward the communicative function of texts. Through the prompt template module and the dashboard, the teacher or researcher is always in charge of the pedagogical intent embedded into the prompt and can oversee the generated LLM output.

Prompt Engineering Guidelines for Social Feedback Generation

To ensure that LLM outputs adhere to the theoretical principles discussed in this article and avoid reverting to the default "teacher-evaluator" persona often inherent in standard models we established preliminary prompt engineering guidelines for the predefined *yourMoment* templates.

Basic Theoretical Alignment

As established above, the LLM must be shifted from a vertical/evaluative stance to a horizontal/social stance. Therefore, prompts should explicitly instruct the LLM to ignore "correctness." The AI should not act as an editor fixing errors, but as a reader experiencing a text. We recommend including some form of the following text snippet: "Do not mention grammar, spelling, or sentence structure unless it makes the text literally impossible to understand. Focus only on [text genre specific aspects], the ideas, the emotion, and the flow."

Additionally, it can be helpful to include a list of negative constraints in the prompt to strip away "teacher-evaluator" vocabulary, e.g.: "Do not use the following words or their synonyms: structure, introduction, conclusion, narrative arc, pacing, grammar, spelling, punctuation, commendable, improve, suggestion."

Persona Specification

To operationalize the simulated external audience, the prompt must define a specific persona with limited knowledge and biases. The persona must not know or make inferences about what the writer's intentions are, only what is on the page. Therefore, we advise to include: "You do not have access to the author's mind. If a connection is missing in the text, you are confused. You cannot infer missing information."

To include opportunities for the students to engage in perspective taking the prompt should include motivation or biases of the simulated reader: "You like video games and funny stories, but you get bored easily if a text is too long or confusing" or "You are a sceptical school principal, who does not want to waste money."

Feedback Generation Mechanisms

To foster social feedback literacy and revision competence, the LLM must not provide direct suggestions for revision; it must only provide a reader's reaction as a stimulus for the student. To ensure the feedback is subjectively formulated and does not sound like objective truth, we advise the prompt to include something like "Use exclusively 'I-messages'. Say 'I felt lost here' instead of 'This paragraph is unclear.' Say 'I stopped believing you' instead of 'The argument is weak.'".

As LLMs are developed and tuned to be helpful assistants, we advise to explicitly prompt against this helpfulness to simulate authentic social friction. A prompt should include some text snippets like: “Never use phrases like ‘good job,’ ‘here is a tip,’ or ‘you should’. Do not structure your response as a ‘sandwich’ (praise-critique-praise). Be raw and reactive.”

Age-Appropriateness and Language Complexity

LLMs default to a high reading level (college-educated adult) and often use meta-cognitive jargon (e.g., “narrative structure,” “cohesion”). This creates a barrier for young students. We advise to explicitly constrain the complexity of the output, to ensure the feedback is linguistically accessible to the student writer (e.g. primary education level) while maintaining the persona's specific voice.

Regardless of the persona, we advise to specify the students’ basic characteristics: “Target a reading level of a 9–12-year-old. Limit sentences to a maximum of 15 words. Avoid compound sentences with multiple clauses.”, to ensure readability.

Building on persona agnostic language requirements we advise to add a persona specific description of the targeted language complexity and voice, e.g., for a young, simulated reader: “Use simple, casual vocabulary. It is okay to be energetic or use mild slang. Use reaction words: story, start, end, confused, excited, bored, believe, question, scary, funny” or for an adult simulated reader: “You are an adult speaking to a child. Do not use childish slang but strictly avoid complex words. If you must use a ‘big word’ related to your specific role (e.g., ‘budget’ for a school principal), you must explain it in simple terms.”

DISCUSSION AND FUTURE DIRECTIONS

The theoretical considerations and software architecture presented in this paper supports a paradigm shift in the application of LLMs in writing instruction: moving from Automated Writing Evaluation to “Automated Audience Simulation”. By integrating *yourMoment* with a pre-existing blogging platform like *myMoment*, we demonstrate that the logistical barriers to providing scalable, authentic social feedback can be overcome using persona-driven LLMs.

The significance of this approach lies in its potential to realign classroom practice with the communicative function of writing. When a student receives feedback from a (simulated) peer rather than a teacher focused on assessment, the nature of revision shifts—from fulfilling expectations to engaging in meaningful exchange, such as clarifying intent or enhancing impact.

Limitations and Critical Considerations

Despite the promising potential of this architecture, the utilization of LLMs for simulating external audiences introduces inherent challenges regarding validity and authenticity. While Park et al. (2024) or Wang et al. (2024) demonstrated high

fidelity in persona simulation, LLMs remain probabilistic engines. There is a risk that the simulated feedback may occasionally drift into caricature or fail to grasp the nuanced subtext of a student's narrative. If students perceive the audience as purely artificial, the motivational benefits of the writing community may be diminished.

To address the ethical dimensions of this audience simulation, *yourMoment* mandates the inclusion of a transparency disclosure when posting an LLM-generated comment (e.g., "This comment originates from an AI chatbot"). This ensures ethical transparency regarding the non-human nature of the audience and prevents deception. Data privacy remains a paramount concern in most education contexts. While the *yourMoment* platform processes orchestration logic locally (or on the deployed server), the use of external LLM providers (e.g., OpenAI, Mistral) implies that student's texts are transmitted to third parties. To mitigate these risks, the system architecture in theory supports the integration of local, open-source LLMs to allow for a privacy-preserving deployment.

Finally, we must acknowledge the issue of algorithmic bias. Commercial LLMs are trained on vast datasets that reflect dominant cultural norms and languages, potentially marginalizing specific dialects or cultural contexts found in diverse classrooms. If the simulated external audience implicitly enforces a standard, it risks narrowing rather than broadening the student's communicative range.

Future Directions

The integration of simulated external audiences necessitates a re-evaluation of the teacher's role. In this model, the teacher transitions from being the sole evaluator of text to becoming the "architect" of the writing community. This requires a new form of pedagogical competence: the ability to design and calibrate prompts that elicit pedagogically useful social friction. Instructional practice must focus on teaching students how to interact with these agents not as corrective evaluators, but as distinct personas with specific subjectivities. Teachers will need to guide students in distinguishing between "bad feedback" (hallucination/error) and "challenging feedback" (a valid reader reaction that requires a revision). Students require specific scaffolding to interpret simulated subjectivity without anthropomorphizing the system, necessitating a new branch of feedback literacy focused on LLM interaction.

Consequently, a robust research agenda is required to validate the implications of this approach. We need to move beyond proof-of-concept implementations. Primary research questions should focus on the student's interaction with simulated external audiences and transfer of skills: Does negotiating meaning with an LLM audience improve a student's ability to write for human readers?

The quality of LLM output depends not only on the underlying model's raw power and more on the precise calibration of the simulated persona's constraints and biases. Future design research should therefore explicitly share and evaluate their prompt guidelines when using LLMs to generate learning materials for individual students.

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PRACTICE-BASED RESEARCH ON ACQUIRING SUSTAINABLE DEVELOPMENT SKILLS THROUGH TEACHING MATHEMATICS

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ABSTRACT

The integration of Education for Sustainable Development (ESD) across all subjects and all education levels is essential. Nevertheless, there is a lack of practical applications on integrating ESD in mathematics teaching and learning. This paper addresses the gap in the relevant literature by presenting the implementation of mathematics activities that were designed with the aim to empower the learners and to promote, through collaborative work, skills and values which are necessary for learning for sustainability. The study took place in a typical Greek primary school and the results indicate that the pupils enjoyed the process, constructed the desired mathematical knowledge and at the same time acquired valuable sustainable development skills.

INTRODUCTION

Global sustainability is a key issue for the development of society as it shapes prospects for the quality of life in the future (Vintere, 2018). One of the 17 United Nations global sustainability goals is quality education (United Nations Department of Economic and Social Affairs, n.d.) and in fact, Wals (2022) stresses that education is a key component of creating a more sustainable world. More specifically, Education for Sustainable Development (ESD) gives learners of all ages the knowledge, skills, values and agency to address interconnected global challenges (UNESCO, n.d.).

Therefore, the integration of ESD across all subjects and all education levels is essential. Nevertheless, Hui-Chuan and Tsung-Lung (2022) point out that "issues concerning how…ESD can be integrated with mathematics teaching and learning in schools remain poorly understood" (p.2533).

The study presented here aims to address this gap in the relevant literature by providing practical ideas on integrating sustainability into mathematics teaching and learning.

THEORETICAL FRAMEWORK

Perkkilä and Joutsenlahti (2021) point out that "good teaching and learning that matters lasts for life, and both are inherently sustaining processes. Supporting and maintaining such deep aspects of teaching and learning, which endure and foster sophisticated understanding and lifelong learning for all, builds the main core for sustainable development in education" (p. 164).

Therefore, mathematics, as a school subject, should provide an opportunity to learn critical thinking, problem-solving, and contextual understanding, providing a lingua franca that supports relationships between disparate communities and facilitates learning within other disciplines (Nicol et al., 2020). D'Ambrosio (2015) points out that mathematics teaching for sustainable development should be based on problem solving, modelling and projects and should incorporate a deeper reflection about people, nature and society. Similarly, González, Agudelo and Salinas (2020) stress that critical to the pedagogy of sustainability is the development of 21st century skills such as critical thinking and problem solving, collaboration, communication, creativity and innovation.

Hui-Chuan and Tsung-Lung (2022) found out that ESD, despite its importance, is rather uncommon in mathematics teaching in actual classrooms. They speculate that this might be due to the fact that "reinvented mathematics" as described above might be challenging for teachers to teach. Therefore, they stress that research on ESD in mathematics should focus on providing [practical] support for its implementation.

One study that attempts to provide such support is reported by Perkkilä and Joutsenlahti (2021). The authors propose that a practical way to incorporate ESD into mathematics classroom teaching would be to orchestrate "collaborative mathematical thinking". This teaching approach includes working in groups, being involved in meaningful mathematical discussions and sharing mathematical insights and ideas. The authors suggest that this type of work promotes "sustainable development skills" such as: problem solving, critical thinking (which involves the construction and critique of arguments), modelling with mathematics, using appropriate tools, learning to work together and participation in decision making.

Perkkilä and Joutsenlahti (2021) tested their approach with university students which were prospective teachers. The study reported here adopted the basic principles of their approach but carefully redesigned them for primary school pupils.

METHODOLOGY

The research project presented here was a teaching experiment (Steffe & Thompson, 2000) on designing and implementing a "collaborative mathematical thinking" approach suitable for primary school pupils. The experiment took place in a typical

Greek primary school in Athens and all of its students (110) took part in it. During a whole school day, the pupils were not taught their usual school curriculum. Instead, they worked in groups of four on challenging but fun mathematical activities within a real-world context. Different tasks were designed for different age sets by a group of university researchers. Throughout the "different" school day, the researchers acted as teachers, initially by setting the rules for "collaborating through discussion" and then by facilitating the pupils' work.

In this paper, the focus is on the course designed for the 5th and 6th Year classes (10-12 years old). It included activities which had "traveling" as their common theme. The aim was for children to work collaboratively on problem solving while tackling issues that are related to travels and traveling. The mathematical concepts that the pupils were expected to explore, were "time measurement", "introduction to combinations", "manipulation of data sets" and "lines and geometric shapes". During their explorations they were also expected to cultivate the "sustainable development skills" mentioned above.

A qualitative analysis methodology was adopted. Data were collected from observations, photographs of the pupils' work and interviews before and after the intervention. The transcriptions, notes and photographs were then analysed by adopting a thematic analysis approach and a "thematic episode" as a unit of analysis. This was defined as the total of the pupils' dialogues, acts and pieces of work related to a "theme".

A combination of deductive and inductive coding was adopted during the analysis. The initial codes were the expected sustainable development skills: "Problem Solving", "Critical Thinking", "Modelling", "Creativity", "Innovation", "Collaboration", "Communication" and "Participation in Decision Making". Then, the data examination yielded several sub codes. For example, the codes "Evaluation of Argument", "Acceptance of Argument" and "Construction of Argument" were all sub codes for "Critical Thinking".

Two typical thematic episodes are presented below.

RESULTS

At the beginning of the day, the researchers/teachers introduced themselves and outlined the activities that would follow. The children were divided into groups and were informed that their day was labelled "Travel the World" and that they should work within their groups in order to provide ideas and solutions to issues related to traveling. They were also advised that they should work collaboratively, support their opinions with the appropriate arguments, discuss all the ideas presented and agree to a decision. Throughout the day, the researchers made sure that in every group, the members followed these rules.
The researchers tried to "immerse" the children in the theme and to trigger their imagination, by showing a short movie based on the novel "Around the World in Eighty Days" and its main character Phileas Fogg (Verne, 1873). They then discussed the movie and the differences between travel in the past and today.

After talking about and comparing their own travels they were ready to tackle the tasks of the day. These were presented in the form of the following 6 questions:

- Around the world on a plane: How will you plan your route?
- How can you sit during a flight?
- How can you combine your clothes to create outfits for your trip?
- Dropping off luggage in the airport: How will you open your locker?
- Plane window views from around the world: How can you recreate them?
- Flags, flags, flags! Are there any rules in creating them?

The first thematic episode comes from the "How can you sit during a flight?" activity which aimed to introduce pupils to the mathematical concept of "combinations". At the outset, each group was given the picture of three airplane seats (which can be seen in Figure 1) and were asked to find all the different ways that three friends can sit in them.

Figure 1. (Source: MEDIAPRODUCTION/GETTY IMAGES)

The children were told that they could use the picture as well as the real chairs available for them in the space they were working. They were also given a worksheet where they were advised to record their work.
A group of four girls experimented with enthusiasm by sitting on chairs in different ways. At one point, they got really confused as to what they should record on their worksheet. Then one of them suggested:

1 Girl1:Let's name the friends A, B and C in order to write their combinations!

2 Girl2: So, if A sits on the first seat on the left…we can write…ABC…and also ACB.

3 Girl3: Let me write that down. *Girl3 writes down ABC and ACB.* Now…if B sits on the first seat on the left…*Girl3 thinks about it.*

4 Girl2: It will be…BAC and BCA. *Girl3 writes that down as well.*

5 Girl4: The last one! If C sits on the first seat on the left, it will be CAB and CBA!

6 Girl3: So we have…ABC…ACB…BAC…BCA…CAB…CBA. That is 6!

The girls worked together effectively: one of them offered to record the different positions and the rest provided all the necessary information orally, indicating an unproblematic division of labour. A snapshot from their work can be seen in Figure 2.

Figure 2. *Group Work*

At the beginning of this episode, one member of the team suggested a method of modelling the situation mathematically. Another member accepted the argument which implies that she evaluated it beforehand. Moreover, she enhanced the argument by providing a method (a tool) for dealing with the situation. Finally, although the solution was given by Girl3, it is obvious from the excerpt, that it was the result of the collaboration and discussion of the group. It is also worth noticing that the girls seemed very happy working together and they were committed in finding a solution. The "collaborative mathematical thinking" during this episode cultivated the sustainable development skills that can be seen below as "codes" corresponding to the children's utterances and actions.

Episode 1

Actions/Dialogue	**Codes/Skills**
Experimentation with Chairs	Creativity/Modelling
Utterance 1	Modelling/Critical Thinking/ Construction of Argument
Utterance 2	Critical Thinking/Evaluation of Argument/ Acceptance of Argument/ /Collaboration/ Proposal of a Tool/Construction of Argument/Creativity/Innovation
Utterance 3	Participation in Decision Making/ Communication/Collaboration/ Critical Thinking/Construction of Argument/ Proposal of a Recording Method/ Creativity
Utterance 4	Critical Thinking/ Evaluation of Argument/ Acceptance of Argument / Construction of Argument/ Participation in Decision Making /Communication/Collaboration
Utterance 5	Critical Thinking/ Evaluation of Argument/ Acceptance of Argument/Construction of Argument/Participation in Decision Making/Communication/Collaboration
Utterance 6	Critical Thinking/Evaluation of Argument/ Acceptance of Argument/ Participation in Decision Making/Communication/ Collaboration
Whole excerpt	Problem Solving/Critical Thinking/ Participation in Decision Making/ Communication/Collaboration

The second episode comes from the "How can you combine your clothes to create outfits for your trip?" activity which aimed to develop further the concept of "combinations". The pupils were told that they needed to think about their outfits before starting their trip. Their suitcase had only enough space for three trousers, six tops and two pairs of shoes. They needed to discuss how many different outfits they could create from them. Each group was given pictures of trousers, tops and pairs of shoes which could act as visual aids for their investigations.

The group of the four girls mentioned above, started working excitedly. Initially, they created outfits randomly, discussing what combinations they liked best. A snapshot from their work can be seen in Figure 3.

Figure 3. *Group Work*

After experimenting freely for a while, they decided to be more systematic:

1 Girl2: I think we can do the same as we did with the airplane seats…

2 Girl3: Mm…how can we do that? It can't be done with clothes!

3 Girl1: We can! We can take one pair of trousers *Girl1 holds a picture with one pair of trousers* and match it with the tops and the shoes.

4 Girl2: Yes, that's right! But first, we need to keep the same pair of trousers and top and change the shoes!

5 Girl3: So, let's take one pair of trousers aside *Girl3 keeps one picture*. For this, we will have 2 options.

6 Girl4: So, for all the trousers, we will have 6 combinations!

7 Girl2: And if we change the tops we will have…6x6…

8 Girl3: 36! *Girl3 shows the combinations of pictures to all of them*.

Once again, the girls worked together effectively: one of them (the same as in the previous activity) offered to combine the pictures (to record the different positions) and the rest provided all the necessary information orally, indicating (once again) an

unproblematic division of labour. Moreover, the "collaborative mathematical thinking" during this episode provoked the same sustainable development skills that were evident in the first episode. In fact, such skills were apparent in children's work during the whole "Travel the world" day and are summarized in Figure 4.

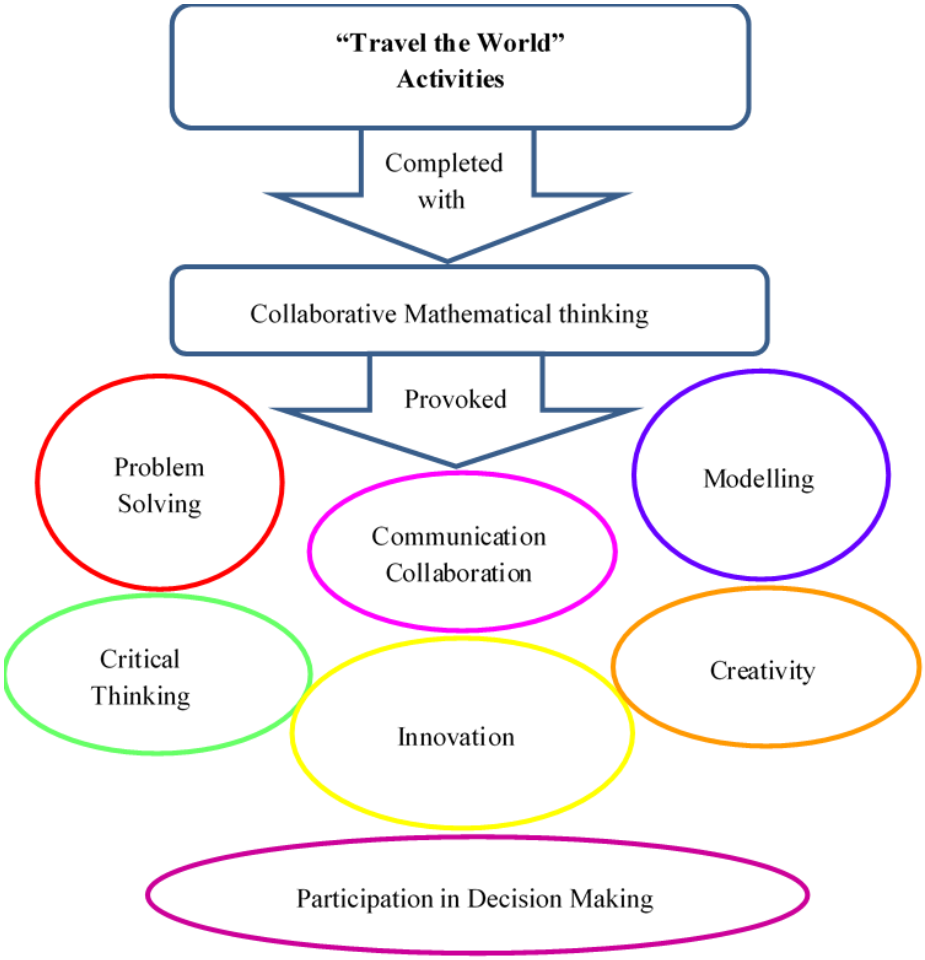

Figure 4. *Sustainable Development Skills Provoked by the Project Activities*

It should be stressed that the general categories of skills presented in Figure 4 include several sub categories: Evaluation, Acceptance and Construction of Arguments, Proposal of Tools and Methods etc.

CONCLUSION

Mathematics can be a valuable tool for identifying, comprehending and solving problems in the surrounding society (Widiaty and Juandi, 2019) and hence a "key" aspect for ESD. The research study presented here provides practical guidelines for integrating ESD into mathematics teaching and learning.

A number of mathematical activities were designed with the aim

(a) to be fun
(b) to be challenging and
(c) to be used as a "vehicle" for a "collaborative mathematical thinking" teaching approach appropriate for primary school children.

The two thematic episodes outlined above indicate that all the pupils involved enjoyed participating in the project and very quickly became agents of their own learning. They were aided in constructing mathematical knowledge for specific topics as well as acquiring "sustainable development skills". These are crucial and valuable skills because they can be used "to solve and model ESD-based mathematical problems…in the social, economic and environmental fields…and effectively support [people's] lives" (p. 163, Perkkilä and Joutsenlahti, 2021).

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INTEGRATING THE SOCRATIC METHOD AND THE 4E FRAMEWORK IN AI-ENHANCED LEARNING ENVIRONMENTS

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ABSTRACT

Integrating Socratic questioning with a 4E motivational-cognitive model (Effort, Enthusiasm, Expectation, Easy), we developed an AI-driven scaffold that transforms passive fact-retrieval into active, reflective inquiry. The Socratic Playground for Learning (SPL), powered by GPT-4, generates personalized prompts, delivers immediate feedback, and analyzes user patterns to adapt Socratic strategies in real time. In a 16-week study (n = 128), SPL users showed significant gains in intrinsic motivation, self-efficacy, metacognitive strategy use, and self-regulation (all $p < 0.001$) compared to non-users. Qualitative improvements in questioning depth suggest that extended deployment may translate into higher-order learning outcomes. We discuss implementation guidelines for curricula, teacher training, and AI platform design, and outline directions for longitudinal, emotion-aware, and cross-cultural studies.

INTRODUCTION

Questioning serves as a pivotal mechanism for fostering knowledge acquisition and promoting deep learning by encouraging students to actively construct new understanding. The most recent curriculum standards for subjects such as mathematics, physics, chemistry, and biology emphasize the cultivation of problem awareness and inquiry skills as fundamental educational objectives. However, the conditions in the classroom frequently impede students' ability to pose inquiries, while educators encounter challenges in addressing these inquiries within the constraints of limited teaching time. The advent of large language models (LLMs), exemplified by ChatGPT, has engendered a transformative paradigm for addressing these challenges. By providing instantaneous and customized responses to students' inquiries, LLMs facilitate a customized learning experience (Kasneci et al., 2023).

Despite the potential of LLMs, their effectiveness in educational settings is often undermined by the quality of student questions. Research indicates that students

frequently pose low-level, factual, or descriptive questions, which elicit superficial responses from AI, failing to stimulate critical thinking or deep cognitive engagement (Chiu, Xia, Zhou, Chai, & Cheng, 2023). Such interactions render LLMs akin to "unreliable teammates," unable to meet students' learning Expectation and hindering the development of higher-order thinking skills(Milano, McGrane, & Leonelli, 2023). To address this, educators must guide students to formulate complex, analytical questions that leverage AI's capabilities for meaningful feedback (Kasneci et al., 2023; Yang, Ogata, Matsui, & Chen, 2021).

Socratic questioning, characterized by challenging assumptions, evaluating evidence, and fostering evidence-based reasoning, provides a robust framework for enhancing student-AI interactions (Paul & Elder, 2016). This approach encourages students to explore underlying reasons, critically evaluate ideas, and generate sophisticated questions, thereby deepening cognitive processes and promoting critical thinking (Xie, 2023). By integrating Socratic questioning into dialogues with LLMs, students can engage in reflective inquiry, moving beyond surface-level queries to achieve true deep learning (Su, Lin, & Lai, 2023).

Building on this foundation, the current study developed a Socratic question scaffold to support students in crafting high-quality questions for LLMs.

The integration of Socratic inquiry into student-AI interactions offers a promising approach to fostering deep learning by guiding students to pose analytical and evaluative questions. This study implemented a scaffold grounded in Socratic principles to enhance the quality of questions directed at large language models (LLMs), such as ChatGPT. The scaffold was designed to prompt students to formulate questions that challenge assumptions and require evidence-based reasoning, thereby eliciting more robust and relevant AI responses(Qi et al., 2023). Employing content analysis and lagged sequence analysis, the study evaluated changes in students' question depth, sequence, and structure before and after scaffold implementation.

Findings demonstrated significant improvements in question complexity, with students transitioning from factual and descriptive queries to analytical and evaluative ones, as measured by Bloom's Taxonomy(Collins, 2014; Rahayu, 2018; Shcheglova, Costley, Gorbunova, & Lange, 2025). Lagged sequence analysis further revealed enhanced question structures, characterized by iterative and recursive patterns that deepened cognitive engagement (Al-Hossami, Bunescu, Smith, & Teehan, 2024; Ding et al., 2024). These results align with prior research on AI-driven scaffolding, which underscores the importance of structured guidance in transforming LLMs into effective learning partners(Kasneci et al., 2023). For instance, similar Socratic scaffolds in programming and mathematics education have been shown to improve students' problem-solving and critical thinking skills by fostering more sophisticated question-asking behaviors(Boli & Bartlett; El-Zakhem, 2016).

The efficacy of the Socratic scaffold lies in its ability to bridge the gap between students' initial question-asking tendencies and the cognitive demands of deep

learning. By encouraging recursive thinking and reflective inquiry, the scaffold enables LLMs to deliver responses that support higher-order cognitive processes, thereby enhancing students' critical thinking and learning outcomes (Qi et al., 2023). These findings have significant implications for educational practice, particularly in distance learning contexts where personalized AI interactions can address individual learner needs. Educators are encouraged to adopt Socratic scaffolds to optimize AI-supported inquiry, ensuring that LLMs serve as dynamic tools for fostering intellectual growth. Future research should explore the scalability of such scaffolds across diverse disciplines and investigate their long-term impact on student learning trajectories.

The 4E framework (Wu, Chang, & Ye, 2023) classifies learners along four dimensions—intrinsic Motivation, metacognitive Strategies Use, self-Efficacy, and test anxiety—to predict academic performance more effectively than test scores alone. In this study, we extend the 4E model by integrating AI-driven personalization with the Socratic method, yielding an innovative 4E-based Socratic questioning framework that adaptively tailors prompts to each learner's unique profile.

The proposed 4E-based Socratic questioning framework, grounded in the Socratic inquiry principle, facilitates students' construction of analytical and evaluative inquiry, thereby enhancing the depth and complexity of AI responses. Concurrently, the 4E dimensions and Socratic dialogues are mapped to instructional styles, such as Effort for Probing, Enthusiasm for Reflective, Expectation for Comparative, and Easy for Clarifying.

This study employed content analysis and lagged sequence analysis to examine changes in the depth, sequence, and structure of students' questions before and after the implementation of the scaffold. The findings indicated substantial increases in the complexity of the questions and the cognitive engagement of the participants, which is in alignment with prior studies on the use of AI-driven inquiry-based learning scaffolds. These results underscore the efficacy of scaffolds in transforming Large language models (LLMs) into effective learning partners, fostering critical thinking, and facilitating deep learning outcomes.

INTRODUCTION

The Socratic Method

The Socratic method, which originated in classical Greek philosophy, is regarded as one of the earliest and most influential pedagogical approaches for critical inquiry. This method is rooted in Plato's dialogues, including The Republic and Symposium. It employs systematic questioning to dismantle assumptions and expose interlocutors' latent beliefs (Vlastos, 1991). Its historical evolution has established a tradition of intellectual engagement, where iterative dialogue fosters self-reflection and rigorous debate, positioning knowledge not as static truths but as dynamic constructs shaped through dialectical exchange (Scott, 2002).

A distinguishing characteristic of the Socratic method is its classification of question types. The employment of clarifying questions, such as "How would you define 'justice' in this context?" serves to establish conceptual precision, thereby ensuring shared understanding among participants (Paul & Elder, 2016). Probing questions (e.g., "What evidence supports your conclusion?") have been shown to excavate the rationale behind claims, while comparative questions (e.g., "How does this perspective differ from utilitarianism?") and reflective questions (e.g., "Why might your initial assumption be incomplete?") have been shown to cultivate metacognition by juxtaposing viewpoints and scrutinizing personal biases (Wu et al., 2023).

The efficacy of the Socratic method in fostering critical thinking and deep learning has been validated through empirical studies. For example, Burns et al. (2016) demonstrated that structured Socratic dialogue significantly improved critical thinking skills in a psychology capstone course, with notable gains in students' ability to analyze and evaluate arguments(Burns, Stephenson, & Bellamy, 2016). Similarly, Kost et al. (2015) found that Socratic questioning in medical education enhanced deep learning outcomes by encouraging medical students to engage in iterative clinical case analysis, fostering deeper conceptual understanding(Kost & Chen, 2015). However, scaling this method in technology-mediated environments presents significant challenges. As Fakour and Imani (2025) note, the exploratory depth of Socratic inquiry—including personalized follow-up questioning—is often undermined by rigid algorithmic interactions in AI-based systems. For instance, while AI tutors leveraging large language models (LLMs), such as Socratic chatbots, can simulate dialectical exchanges, they risk prioritizing breadth over depth, reducing complex debates to formulaic question-and-answer sequences (Fakour & Imani, 2025).

The 4E Framework

The 4E framework, initially proposed by Wu and Chang, serves as an integrated motivational-cognitive model that optimizes learning processes through four synergistic components: Effort, Enthusiasm, Expectation, and Easy(Wu et al., 2023). This framework draws theoretical foundations from self-determination theory and social cognitive theory, while addressing contemporary challenges in digital learning environments.

1. **Effort:** Effort entails persistent engagement in cognitive refinement through reflective questioning and self-regulated learning strategies, enabling learners to challenge assumptions and advance from surface-level comprehension to deep conceptual understanding(Entwistle & McCune, 2004; Wolters, 2003). Neurocognitive research indicates that optimally challenging tasks, without reliance on extrinsic rewards, enhance intrinsic motivation for sustained effort in learning (Murayama, Matsumoto, Izuma, & Matsumoto, 2010). Adaptive learning systems, which monitor behavioral patterns within learning management platforms, are recommended to maximize effort and promote self-regulation, thereby supporting effective learning outcomes (Azevedo & Hadwin, 2005; Martin, Chen, Moore, & Westine, 2020).

2. **Enthusiasm:** Enthusiasm, characterized by intrinsic motivation, fosters engaged and self-directed learning (Ryan & Deci, 2000). Prior Research indicates that intrinsically motivated learners demonstrate enhanced knowledge retention through self-regulated exploration of complex concepts (Pintrich & De Groot, 1990). Adaptive learning systems that employ dynamic difficulty adjustment algorithms are recommended to enhance enthusiasm by tailoring challenges to individual competency levels, thereby promoting sustained engagement and effective learning outcomes (Azevedo & Hadwin, 2005; Martin et al., 2020).

3. **Expectation:** Expectation here refers to the development of self-efficacy through gradual self-Expectation(Bandura, 1997; Schunk, 1991). Prior research shows that learners with high self-efficacy demonstrate significantly greater persistence and engagement in metacognitive strategies, enhancing academic performance (Pajares, 1996). Adaptive learning systems that implement scaffolded micro-achievements, tracked via milestone completions and competency dashboards, are recommended to build self-efficacy, aligning with goal-setting theory (Azevedo & Hadwin, 2005; Locke & Latham, 2002).

4. **Easy:** Easy means cognitive load management, facilitated by adaptive technology scaffolding, enhances learning efficiency by reducing extraneous cognitive demands(Sweller, Van Merriënboer, & Paas, 2019). Research challenges the assumption that digital natives inherently adapt to technology, emphasizing the need for explicit instructional support (Gallardo-Echenique, Marqués-Molías, Bullen, & Strijbos, 2015). Adaptive learning systems that leverage AI-assisted note synthesis and retrieval-practice optimization are recommended to offload cognitive demands, supporting knowledge construction and retention (Fiorella & Mayer, 2017). These technologies significantly reduce extraneous cognitive load, improving learning outcomes (Paas, Renkl, & Sweller, 2003).

The 4E framework can also be combined with Socratic questioning, as shown in Table 1. This integration creates a structured approach to cognitive engagement where each dimension of the 4E model aligns with a specific type of Socratic question. The Effort dimension corresponds to Probing questions that push learners to examine evidence and reasoning behind their viewpoints. The Enthusiasm dimension pairs with Reflective questions that encourage students to explore interests and challenge existing thinking patterns. Expectation refers to learners' self-efficacy and goal-setting, operationalized through comparative Socratic questions that contrast perspectives. This dimension utilizes Comparative questions that prompt analysis of different perspectives and theoretical frameworks. Finally, the Easy dimension employs Clarifying questions that reduce cognitive load by establishing clear conceptual foundations. This systematic mapping provides educators with concrete examples of how to implement each questioning strategy to foster critical thinking while addressing motivational and cognitive aspects of learning simultaneously.

Table 1. *Alignment of Socratic Question Types with the 4E Framework Dimensions and Instructional Examples*

4E Dimension	Question Type	Example
Effort	Probing	"Why do you think this evidence supports your viewpoint?"
Enthusiasm	Reflective	"Which perspective interests you most? How does it challenge your original thinking?"
Expectation	Comparative	"What makes this perspective unique compared to other theories?"
Easy	Clarifying	"Please specify your definition of this concept."

Challenges in AI-Enhanced Learning Environments

AI-enhanced learning faces challenges as users often pose superficial, fact-based inquiries that fail to leverage LLMs' analytical capabilities. This phenomenon can be attributed to the challenges users encounter when formulating complex queries that explore assumptions, relationships, or contextual implications. Educational research has demonstrated the efficacy of structured question scaffolds in addressing this challenge. Socratic frameworks are a method of organizing questions into categories based on their function. These categories include clarification, probing, comparative, and reflective questions. The purpose of these categories is to guide students in conducting deeper inquiries. Evaluation rubrics facilitate the refinement of questions in accordance with quality benchmarks. These tools are designed to break down complex thinking into manageable steps while maintaining rigor. Research has demonstrated that such interventions enhance the design of inquiry, transitioning from inquiries into the nature of X to the influence of X on Y under diverse conditions. This transformation facilitates a shift from mere recall to systems-level analysis. This pedagogical approach fosters the development of transferable critical thinking skills while simultaneously enhancing LLM interactions. By establishing a connection between the capabilities of artificial intelligence (AI) and the patterns exhibited by users in their inquiries, scaffolds have the potential to transform the role of language models (LLMs) from mere sources of information to collaborative partners in conceptual exploration. This transformation aims to optimize the educational value of AI by facilitating self-regulated, purposeful inquiry.

AI-ENHANCED LEARNING ENVIRONMENTS

Technological Foundations and AI Capabilities

Recent advancements in large language models (LLMs), such as GPT-4 and Grok 3.0, have revolutionized educational technology by enabling dynamic, context-sensitive interactions in learning environments. These models function as adaptive tutors capable of generating personalized feedback and tailored content in real time, aligning with the increasing need for equitable education. Brown et al. (2020) demonstrate that LLMs can simulate human-like reasoning and adjust responses to diverse learner inputs, thereby promoting self-regulated learning and intrinsic

motivation (Brown et al., 2020). Moreover, Bommasani et al. (2021) emphasize the potential of these models to support complex cognitive processes and cater to individual learning paces in real time (Bommasani et al., 2021). By accommodating individual cognitive loads, these systems offer scalable solutions that address both physiological and metacognitive gaps, enhancing educational equity without compromising academic rigor.

The integration of formative assessment tools—such as intelligent tutoring systems and adaptive platforms—further amplifies personalized learning outcomes by delivering immediate, individualized feedback. Nicol and Macfarlane-Dick (2006) underscore the importance of self-assessment and efficacy-building frameworks in optimizing student engagement (Nicol & Macfarlane-Dick, 2006). Complementing this, VanLehn (2011) provides evidence that intelligent tutoring systems can approach the effectiveness of human tutors in boosting learning gains (VanLehn, 2011). However, the effectiveness of these AI interventions ultimately hinges on the learners' ability to pose rich, multidimensional questions that probe deeper understanding—a challenge highlighted by Shute (2008), who notes that continuous, iterative practice is vital for cultivating higher-order thinking skills (Shute, 2008).

The Socratic Playground for Learning (SPL)

The Socratic Playground for Learning (SPL) is grounded in a multi-agent psychological simulation architecture (Hu, Tong, & Xu, 2025), where each Socratic prompt emerges from an internal deliberation among agents representing Self-Efficacy, Math-Anxiety, Goal-Pursuit, and Spatial-Reasoning. This transforms SPL from a black-box tutor into a transparent, theory-driven cognitive model of human inquiry. In what ways can SPL be integrated into a curriculum? In the context of mathematics education for middle school students, three distinct learning modalities have been identified: foundational learning, transformational learning, and social-emotional learning. SPL is capable of the first task, but humans must perform the second and third tasks. As shown in Figure 1, Socratic Playground for Learning(SPL) provides two functional usage groups: teacher mode and learner mode based on special aim. SPL has been developed on the basis of advanced transformer-based language models, including GPT-4. This innovative system integrates pedagogical frameworks with real-time adaptive mechanisms. The architecture of the system under consideration employs dynamic natural language processing (NLP), scenario generation, and continuous learner profiling to deliver personalized instruction. The system utilizes Socratic questioning techniques, fueled by large language models (LLMs), to identify misconceptions and promote critical thinking. It aligns with principles such as the Zone of Proximal Development for scaffolding.

Depending on whether the user operates in teacher mode or learner mode, SPL adapts its questioning strategies and feedback mechanisms accordingly. These modes function in a manner that adapts to the learner's progression, progressing from the identification of knowledge gaps to the attainment of mastery. In Assessment Mode, preliminary assessments identify cognitive deficiencies, thereby initiating customized Tutoring Mode dialogues in which LLMs generate contextualized

analogies and counterarguments. Vicarious Mode facilitates observational learning through simulated group discussions, while Gaming Mode reinforces concepts via competitive problem-solving. The system's prompt engineering, based on the JSON (JavaScript Object Notation) language, ensures that interactions are modular and aligned with pedagogical principles. These interactions are tracked through metrics such as misconception resolution and the depth of self-reflection, providing insights into the learner's progress. The SPL would play a role in determining the efficacy of the method in enhancing critical thinking and academic performance in disciplines such as accounting education. The method is designed to enhance autonomy in learning processes, thereby reducing the instructor's workload.

Figure 1. *Interface of the Socratic Playground for Learning (SPL), Illustrating the two Primary User Roles: Teacher Mode and Learner Mode*

SPL-Enhanced Curriculum Integration and Competency Framework

In the nascent field of human-computer interaction AI, the preliminary phase involves the configuration of three elements: the user, the environment, and the target object. As previously stated in Section 3.2, the SPL is designed to facilitate the teaching objective and deep understanding through Socratic questioning during the foundational learning stage. As illustrated in Figure 2, the fundamental input environment configuration encompasses the tongue, study area, subsample area, and the objective of learning. As illustrated in Figure 2, the objective of the learner is to acquire statistical knowledge as part of a broader study in mathematics. The scope of the study encompasses the verification of hypotheses as a fundamental element of the learning process.

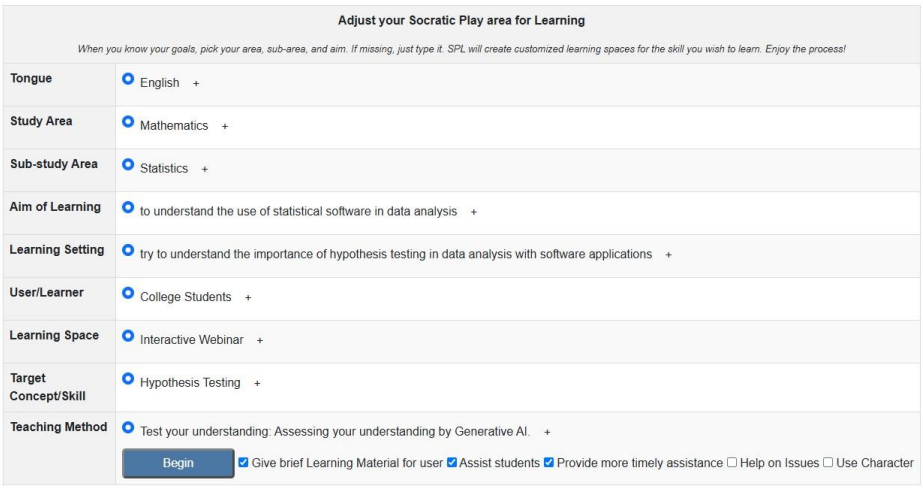

Figure 2. *Configurable Socratic Learning Environment*

Subsequently, user proceeded to the interactive session, which was designed to initiate the review and learning process through a dialogic approach. As illustrated in Figure 3, users must first ascertain the background and purpose of the problem. Subsequently, they attempt to profile the knowledge point and comprehend the entire learning path and adjacent knowledge points. One may inquire, "I want to learn about statistical hypotheses and prepare for hypothesis analysis when writing a paper. Please tell me the stages of learning and the path of knowledge acquisition." Subsequent to the provision of comprehensive content by the AI Tutor Agent, users have the option to engage in online inquiries to acquire authentic case studies and further their education.

As illustrated in Figure 3, after providing a concise overview, the AI Tutor Agent initiates Socratic questioning with the prompt: 'Now consider: What are the subsequent steps to be taken after establishing these hypotheses?" In the event that the user furnishes an incorrect or equivocal response, the system will initiate a series of inquiries and prompts, systematically guiding the user towards the correct response.

Building on learners' mastery of the learning pathway and adjacent knowledge, we apply Socratic questioning to each case and its arising issues to elicit reflective "Enthusiasm." Concise prompts minimize cognitive load, fulfilling "Easy," while subsequent probes after initial responses promote "Effort." Finally, under "Expectation," we conceptually distinguish the tracked concept from its neighboring concepts.

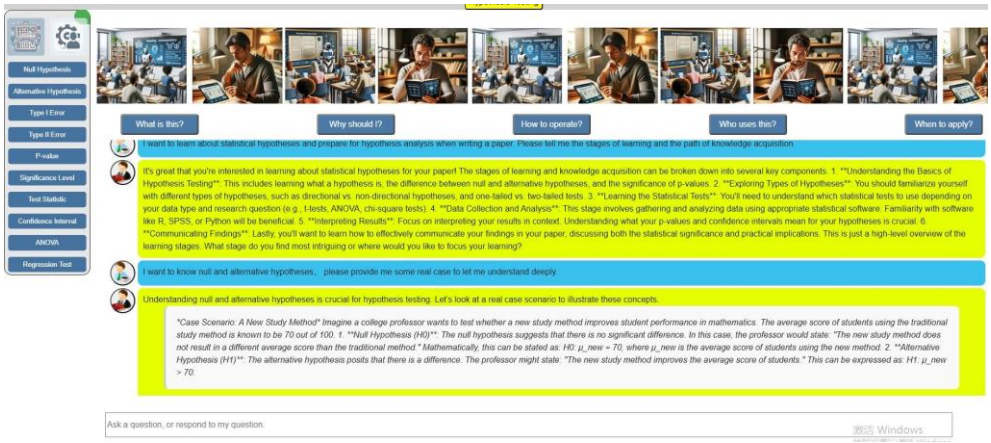

Figure 3. *Intelligent Tutor Dialogue Mode*

CASE STUDY

From March to July of 2024, an empirical study was conducted at the School of Economics and Management, Zhujiang College, South China Agricultural University. The objective of the study was to examine the effectiveness of the Socratic Playground for Learning (SPL) in accounting education contexts. As students frequently encounter difficulties in cultivating high-quality inquiries within AI-enhanced learning environments, we have implemented SPL—an intelligent tutoring system developed by Professor Xiangen Hu at Hong Kong Polytechnic University—to provide scaffolding for Socratic questioning techniques. The 16-week experiment (March-June 2024) involved 128 non-accounting majors, including 47 girls and 81 boys. They are enrolled in a Principles of Accounting course at a private institution in Guangdong Province. The mean age of the participants was 21 years. Seventy-seven participants voluntarily used the Socratic platform, while 41 opted not to participate. No significant differences were found in prior academic performance or motivation questionnaire scores between the volunteer and non-volunteer groups.

The GPT-4–based platform generated personalized Socratic dialogues tailored to each student's course content and inquiry patterns. Under instructor guidance, participants first clarified the target problem, then explored adjacent concepts and knowledge points, and finally requested relevant case examples. They provided background information and materials, selected learning principles and question types, and engaged in multi-turn dialogues designed to enhance cognitive engagement.

The performance of the students was measured through summative assessments, which included final exams, and formal assessments, which included 21 classroom quizzes. Usage data and self-reported experiences were also collected. While exam scores showed minimal differences between users and non-users (Table 2), SPL users demonstrated superior critical inquiry in case studies (p=0.064), suggesting

early-stage cognitive benefits. However, the case study questions exhibited a tendency towards statistical significance (p = 0.064). The utilization patterns exhibited a conspicuous discrepancy in adoption rates between top-performing students (72.41%) and low-performing students (53.57%). The predominant challenge reported by participants at all performance levels pertained to the difficulty in formulating pertinent follow-up inquiries despite having received responses. Although not statistically significant, qualitative improvements in questioning depth and structure were observed, suggesting the necessity of longer implementation periods to achieve measurable performance improvements in AI-enhanced Socratic learning environments.

Table 2. *Comparison of Exam Performance Between Users and Non-Users of the Intelligent Learning System*

Question Type	**Users (*n* = 77)**	**Non-Users (*n* = 41)**	***t***	***p***
Case Study Questions	16.85 (SD = 7.02)	14.33 (SD = 6.76)	1.873	.064
MCQ – Single	13.40 (SD = 2.88)	13.37 (SD = 3.48)	0.057	.955
MCQ – Multiple	7.15 (SD = 3.24)	6.10 (SD = 3.40)	1.637	.104
Fill-in-the-Blank	10.04 (SD = 4.52)	10.12 (SD = 3.40)	-0.089	.930
True/False	10.44 (SD = 1.75)	10.34 (SD = 1.62)	0.297	.767

In addition, the Motivated Strategies for Learning Questionnaire (MSLQ) scale developed by Pintrich (Pintrich, Smith, Garcia, & McKeachie, 1993) was applied to assess the learning motivation of the 118 students in this study. This approach enabled the analysis of motivational differences and strategy preferences under varying motivational states. According to Cohen's criteria, which stipulate that f = 0.10 for small effect, f = 0.25 for medium effect, and f = 0.40 for large effect, each motivation item indicator demonstrated medium to large effect levels. As demonstrated in Figure 4, students who utilized the SPL platform exhibited significantly higher internal motivation ($p < 0.001$), self-efficacy ($p < 0.001$), cognitive strategic use ($p < 0.001$), and self-regulation ($p < 0.001$) compared to non-users. The findings suggest that the SPL system effectively enhances learners' intrinsic interest, confidence in mastering tasks, strategic cognitive engagement, and ability to independently regulate their learning process. In contrast, no substantial discrepancy was observed between the two groups with respect to test anxiety (p = 0.146, n.s.), indicating that the present design of the SPL platform may not adequately address students' emotional responses to testing circumstances. This underscores the necessity for system enhancements to ensure comprehensive support for learners' emotional and academic needs.

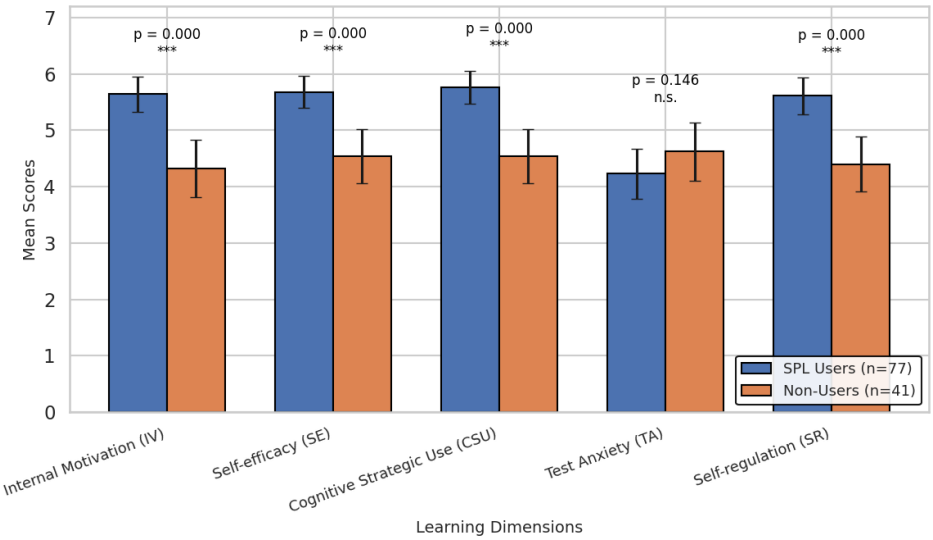

Figure 4. *Comparison of SPL Users and Non-Users Across Learning Dimensions*

PROPOSED SOCRATIC 4E MODEL FRAMEWORK

The empirical study's findings led to the proposal of a Socratic Questioning Framework for Enhancing AI Prompt Engineering and Learning Dynamics, as illustrated in Figure 5.

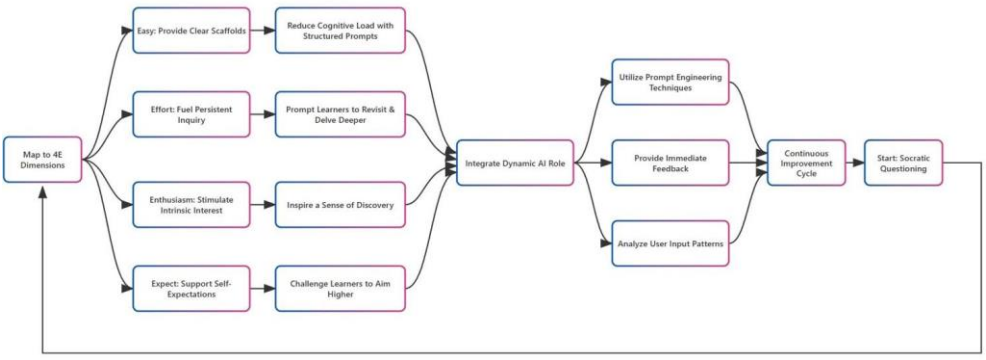

Figure 5. *Framework for 4E-AI Synergistic Scaffolding in Socratic Learning*

Figure 5 illustrates a structured conceptual framework integrating the "4E Dimensions" into an AI-driven educational design cycle, aiming to facilitate deep cognitive engagement through systematic Socratic inquiry. The process initiates from the clear identification of four core pedagogical dimensions (Easy, Effort, Expectation, Enthusiasm), each addressing a distinct aspect of learner cognition and motivation:

1. **Easy:** This dimension employs structured scaffolds designed to minimize cognitive load and prevent information overload. Examples include

predefined templates that guide learners through complex problem decomposition.

2. **Effort:** Persistent deep learning is fostered through iterative questioning strategies. For instance, recurring prompts such as "Analyze this problem from multiple perspectives" encourage sustained intellectual exploration.

3. **Expectation:** This dimension enhances learner self-efficacy by implementing hierarchical goal-setting strategies. Learners are prompted with progressively challenging inquiries (e.g., "Formulate a question exploring relationships between two variables").

4. **Enthusiasm:** Intrinsic motivation and curiosity-driven inquiry are cultivated through open-ended, exploratory prompts (e.g., "Predict which method will produce unexpected outcomes"), thus stimulating deeper cognitive investment.

The central component, Dynamic AI Role Integration, operationalizes these 4E objectives through three adaptive functionalities:

- Prompt Engineering: AI dynamically generates tailored scaffolds contingent upon learners' developmental stages. Beginners receive foundational clarification prompts (e.g., "Is your definition complete?"), whereas advanced learners encounter comparative analysis questions (e.g., "How do the premises of concepts X and Y differ?").

- Immediate Feedback: The AI system evaluates learner inputs in real-time, analyzing both content depth (such as the presence of hypothesis evaluation) and structural coherence (e.g., causal reasoning clarity). Specific, actionable recommendations are subsequently provided (e.g., "Rephrase your question using a 'what if' structure to enhance complexity").

- User Pattern Analysis: Real-time analytics identify learner-specific cognitive tendencies and logical gaps (e.g., frequent reliance on factual queries at the expense of counterfactual reasoning). This analysis informs personalized, data-driven adjustments to instructional approaches.

The final component, the Continuous Improvement Cycle, creates a closed-loop iterative mechanism characterized by:

- Data-driven Iteration: Insights derived from learner interaction patterns are reintegrated into the initial 4E mapping phase. For example, prolonged learner engagement with surface-level factual questions triggers focused reinforcement of the "Expectation" dimension by introducing comparative case dialogues and higher-order cognitive challenges.

- Dynamic AI Adjustment: AI guidance intensity is adaptively modulated based on learner competency progression. This modulation ranges from

direct cognitive interventions (explicitly guiding thought processes) to subtler, indirect questioning (encouraging autonomous exploration). For instance, as learners demonstrate increased proficiency in formulating systematic hypotheses, the AI strategically shifts to an Enthusiasm-driven mode, posing increasingly open-ended exploratory questions ("What variables might introduce potential confounding effects?").

- Integration with Socratic Questioning: Ultimately, the iterative AI-supported questioning process aims to replicate the classical Socratic method of cognitive elicitation, promoting an educational shift from rote memorization toward dialectical reasoning. Empirical evidence of this progression is observable as learners transition from isolated factual queries to sequentially structured, logical inquiries (e.g., "How might economic models adapt if corporations reduce carbon emissions, and what secondary risks could emerge?").

This integrated framework thus systematically enhances learner inquiry through targeted AI-mediated scaffolding, fostering sustained cognitive development and deeper analytical reasoning capacities.

The proposed Socratic 4E Model is operationalized through three strategic pillars: curriculum design, educator development, and technology integration. First, the curriculum and instructional design should integrate dedicated modules and interactive workshops. These modules and workshops should embed Socratic questioning scaffolds into established course structures. Specifically, the development of "Socratic Question Lists" that categorize inquiries into clarification, probing, comparative, consequence, and reflective types can serve as a cognitive blueprint. This structured approach is expected to facilitate question sequencing and elevate the depth of learner inquiry. Secondly, the implementation of comprehensive teacher training and professional development programs is imperative. It is imperative that educators possess explicit methodologies to model high-quality inquiry and to guide learners in formulating, refining, and sequencing questions effectively. The provision of evaluative rubrics and sample question chains will further support teacher efforts in nurturing critical thinking and sustained engagement. This, in turn, will ensure that the integration of the 4E framework is seamlessly aligned with pedagogical objectives.

Thirdly, technology integration is imperative in the transformation of theoretical scaffolds into dynamic, interactive learning tools. It is imperative that AI-enabled learning platforms be enhanced with user interfaces that deliver interactive prompts, offer real-time evaluations of question quality, and facilitate immediate feedback. The implementation of advanced analytics will facilitate continuous monitoring of learner progress in terms of question depth, sequential transitions, and overall inquiry architecture. This, in turn, will enable dynamic refinements in prompt design and scaffold calibration.

CONCLUSION

This paper introduces a human-centered AI benchmark that not only enhances learning but also makes human cognition measurable and evaluable for AI systems. By simulating the internal psychological dynamics of inquiry, our framework offers a testbed for 'Reasonable AI'—where AI must reason, adapt, and interact like a human, not just optimize for accuracy. By mapping Socratic question types to "effort," "enthusiasm," "Expectation," and "ease," and operationalizing them through dynamic prompt design, immediate feedback, and user pattern analysis, the framework addresses common pitfalls of superficial AI interactions. The development of the SPL AI Tutor platform was predicated on the aforementioned framework. A field experiment involving 128 undergraduate students who utilized the SPL learning platform confirmed that SPL users exhibited significantly higher levels of intrinsic motivation, self-efficacy, cognitive strategy use, and self-regulation in comparison to non-users. Despite the modest gains observed in conventional examinations, the enhancement in the complexity of the questions indicates the potential for early cognitive advantages.

The contribution of this study is that in order to improve the effectiveness of AI-supported educational interventions, key implications for practice include embedding Socratic scaffolding in AI platforms to provide a balanced blend of motivational support and cognitive challenges to promote deeper student engagement. Furthermore, the provision of metacognitive guidance skills and assessment criteria to educators is imperative to facilitate effective student guidance and the evaluation of learning progress. Furthermore, the implementation of a closed-loop data cycle has the potential to enhance the efficacy of AI prompts and scaffolding strategies, thereby ensuring an adaptive and personalized learning experience. The integration of these strategies is instrumental in enhancing educational outcomes within technology-enhanced learning environments. Future work should explore long-term learning transfer, emotion-aware AI adaptations, and the generalizability of the Socratic 4E model across diverse educational contexts and cultures.

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MASTER EDUCATED TEACHERS AS DRIVERS OF QUALITY IN VET: THE INTERACTION OF CONTEXT AND EXPERIENCE

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ABSTRACT

Over the past decade, the number of master-educated teacher leaders (MTLs) in Dutch education has increased significantly. However, schools often struggle to harness their potential. While MTLs are expected to tackle complex quality challenges through inquiry, many schools – including those in VET - lack a culture and structure that supports collaborative and inquiry-based practice.
This study in four VET-schools identified three key themes that shape the role of MTLs: 1) driving inquiry-based working in teams; 2) promoting horizontal and vertical alignment within the wider organization; 3) ensuring MTLs' self-care and professional sustainability.
The associated activities are presented in a dynamic model, ranging from those suited to novice MTLs in emerging learning cultures to those of experienced MTLs in more mature contexts. Experienced MTLs may revert to 'beginner activities' when entering new or less-developed environments. MTLs can use this model to choose and reflect on their activities and adapt them to the needs of their context.
The study shows that MTLs can play a vital role in developing supportive organizational conditions for a stronger learning culture in VET, provided they engage in the above activities and adapt them to the specific characteristics of their context.

INTRODUCTION

In response to the growing complexity of educational challenges, schools increasingly need professionals who can engage in reflective, inquiry-based collaboration (Hargreaves & Fullan, 2012; Van den Berg, 2016a; Vangrieken et al., 2017). However, many schools still lack a learning culture that enables this (Teurlings & Hermanussen, 2021). Instead, educators often respond to problems

with quick, surface-level solutions under time pressure, neglecting the depth and deliberation needed for sustainable improvement (Kahneman, 2011).

In the Netherlands, an impetus for improving educational quality was provided in 2008 with the introduction of the '*Lerarenbeurs'* (teacher grant), which offered every teacher the opportunity to obtain a master's degree (see HBO-raad, 2004, 2006a,b). The aim was to support their transition from working in isolation to achieving professional autonomy. This entails excellence in fostering learning processes, contributing to the professionalization of colleagues and expertise in initiating and supporting local educational innovation in relation to developments within the broader school context and beyond (Stuurgroep beleidsagenda lerarenopleidingen, 2006).

Many of the professional profiles of the master's programs in education that emerged from this policy contain elements of *teacher leadership*. Although this term is rarely used in a quasi-egalitarian country such as the Netherlands, it is relevant to link these intentions to an internationally recognized conceptual framework. Although a general definition is still lacking (Shen et al., 2020), teacher leadership can be understood as "teacher agency through establishing relationships, breaking down barriers, and marshaling resources throughout the organization in an effort to improve students' educational experiences and outcomes" (York-Barr & Duke, 2004, p. 263).

Over the years, the number of master educated teacher leaders (henceforth MTLs) in Dutch schools has substantially grown and is among the highest in the OESO (OECD, 2024). Yet, in practice, their potential remains underutilized (Heyma et al., 2017; Sligte & Schenke, 2017; Snoek et al., 2019; Van Kan et al., 2017; Wenner & Campbell, 2017). They often struggle with unclear roles and the need to claim space, time, and recognition within their schools. While formal role definitions are desired by them (Rozendaal et al., 2019), these come with risks, including isolation and excessive centralization, which can undermine their capacity to act as connectors (Akkerman & Bruining, 2016; Hazen et al., 2018).

Driven by the research question of *under which internal and external conditions collaboration between MTLs and design groups contributes to educational quality in Dutch Vocational Education and Training (VET)*, the Consortium Tools for Team Learning was established (see Van den Berg et al., 2023). It brought together both master-educated teachers in the VET sector and educational researchers in a so-called research-practice partnership (Coburn & Penuel, 2016).

Situating this study in Dutch VET is particularly relevant for several reasons, beyond the fact that this context remains comparatively underexplored. VET carries a strong social mandate, as it is crucial for labor market participation, social inclusion, and lifelong learning, making the quality of teaching and collaboration directly consequential beyond the school context. It is also a highly complex sector, given the diversity of student populations, learning pathways, and its dual orientation towards both general education and preparation for specific professions.

Maintaining and improving educational quality is especially challenging due to the large scale and organizational complexity of VET colleges, as well as the required responsiveness to rapidly changing professional fields. This demands that teachers not only provide high-quality instruction but also engage in curriculum development and local educational innovation. Multi-level and multi-actor professional learning is therefore needed to safeguard educational quality (Hermanussen & Smulders, 2020; Van der Meer, 2017; Van der Sanden & Teurlings, 2003). Yet, achieving this has proven to be one of the wicked problems in Dutch VET (Van den Berg, 2016a,b). This suggests that the VET sector may benefit considerably from well-positioned MTLs.

Within the consortium, a four-year participatory action research (PAR; Reason & Bradbury, 2008) project was conducted to address this question (Consortium Tools voor Teamleren, 2022). This paper presents its findings.

CONCEPTUAL FRAMEWORK

In addressing our research question, we made two prior assumptions. First, we assumed that MTLs play a vital role in guiding collaborative inquiry within teams that focus on local practical problems perceived by stakeholders as important and urgent. Second, we assumed that MTLs also foster alignment across the school regarding the improvement of educational quality. Both assumptions served as the two overarching themes guiding the investigation in this study.

Theme 1: Guiding Inquiry Based Working In Teams

Inquiry-based working in teams refers to a collaborative process in which educators jointly investigate, design, and improve their professional practice. The goal is to achieve sustainable educational improvement through joint meaning-making – a social-constructivist approach to innovation emphasizing collaboration and contextual relevance (Anderson & Herr, 1999; Fullan, 2007). Inquiry is viewed not as a separate research activity but as an integrated, reflective, and iterative process embedded in everyday practice (Cochran-Smith & Lytle, 2009). To be effective, it should be action-oriented, focusing on practical interventions (Ponte, 2012) and experiential learning though ‘jumping in’ that encourages teams to ‘think big, start small, but start!’ (Van den Berg, 2016; 2025); design-oriented, leading to tested solutions and professional artefacts (Van Aken & Andriessen, 2011); and participatory, ensuring that those closest to the problem are active co-researchers (Migchelbrink, 2016; Reason & Bradbury, 2008; Van Lieshout et al., 2021). These qualities align closely with teachers’ professional agency and collective learning (Zwart et al., 2012). Within this process, MTLs play a central role in creating safe, productive conditions for inquiry, connecting theory and practice, and guiding colleagues through cycles of reflection and experimentation. By doing so, MTLs help teams move from simply working together toward inquiring together – developing shared understanding, practical knowledge, and professional growth that can endure beyond the immediate project.

Theme 2: Promoting Vertical and Horizontal Alignment

Alignment in educational organizations refers to the continuous effort to build meaningful connections between and within different organizational layers. Rather than a fixed end state, it represents an ongoing search for a dynamic balance between freedom and structure, openness and control, and diversity and coherence (Blomme, 2012; Frissen et al., 2016; Labovitz & Rosansky, 1997). The aim is to create powerful linkages and feedback loops that enable different parts of the organization to reinforce and strengthen one another (Den Boer et al., 2011).

Vertical alignment occurs when design teams and management actively coordinate their ambitions and strategies – aligning bottom-up initiatives with top-down goals. This mutual adjustment fosters shared ownership and creates space for professionals to connect organizational aims to their own motivations and concerns (Den Boer et al., 2011). *Horizontal alignment*, in turn, involves collaboration across departments, programs, or professional networks. It enables teams to build coherence and continuity, especially when innovations require cooperation between multiple stakeholders, such as colleagues, students, or external partners.

Through continuous dialogue and coordinated action, horizontal and vertical alignment together strengthen the organization's learning capacity, making improvement efforts more sustainable and integrated across all levels.

METHOD

Our consortium consisted of five MTLs of which one – in line with principles of working as a research-practice partnership (see Van den Berg et al., 2023; Van den Berg & Rozendaal, 2024) – also was the project leader. Each MTL coached at least one inquiry team. MTLs were locally supported by an interim researcher (IR). Senior researchers (SR) led the overarching multiple case study (see Figure 1).

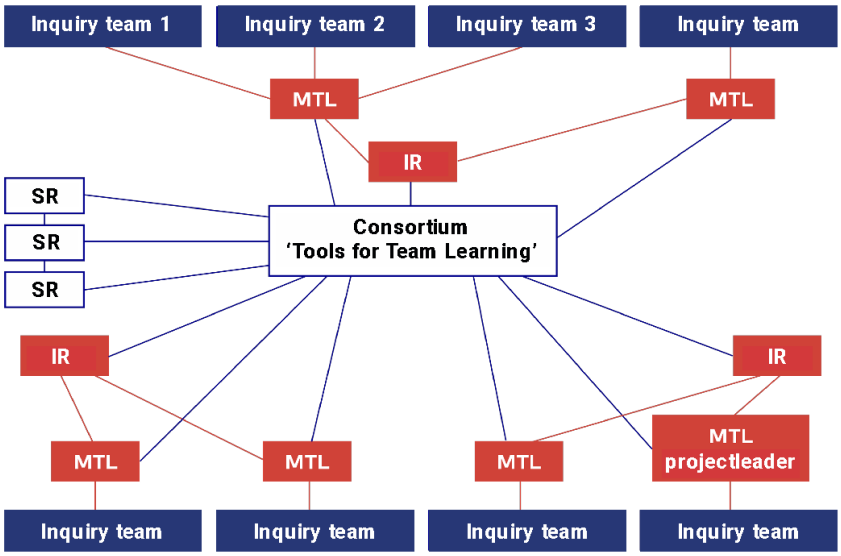

Figure 1. *Organigram of the Tools for Team Learning Consortium*

The study followed a comparative case study approach (Stake, 1995), combining design-based research with participatory action research. MTLs and their design teams worked in at least two iterative cycles. The data collected by these teams were idiosyncratic and included process reports and adapted questionnaires (based on Van den Berg & Vandenberghe, 1995; Verbiest, 2014; Bouwmans et al., 2017; Schenke et al., 2015).

Meaning-making of this idiosyncratic data was conducted through wallpaper roll dialogues with each design team after each of the two project years (see Figure 2; for an extensive description of the method, see Rozendaal et al., 2023; Rozendaal & Van den Berg, 2024). The dialogues were transcribed, after which theorems concerning key learnings about the MTL role were distilled and reviewed by consortium members. These theorems were selected by sorting them into those that were either recognizable to, or considered useful by, MTLs in their respective contexts. The selected theorems were then categorized according to their relevance for novice MTLs or reserved for experienced MTLs. Based on these two sets of theorems –and the discussions surrounding them – we aggregated a bubble scheme, which is further discussed in this paper.

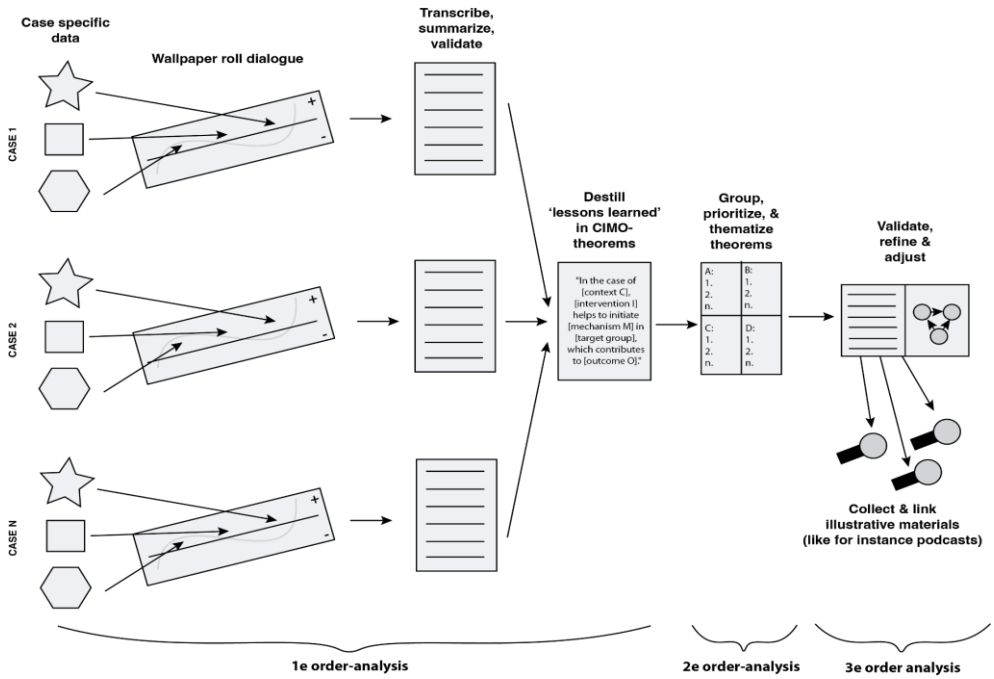

Figure 2. *Quick Overview of the Wallpaper Roll Method*

FINDINGS

In addition to our expectations, a third theme – *self-care* – emerged from the transcripts. We first discuss this new theme in our conceptual framework, after which we turn to the discussion of the bubble scheme.

A Third Theme: Selfcare

Self-care refers to the intentional actions professionals take to maintain their physical and mental well-being – an essential capacity in relational professions such as education, where workload, emotional demands, and responsibility can easily lead to stress or burnout (Hummel et al., 2019; Kennisrotonde, 2018, 2019; Schaufeli & Bakker, 2001). Work pressure results from the balance (or imbalance) between job demands and resources such as autonomy, clarity, and collegial support. Maintaining this balance fosters engagement and well-being, rather than exhaustion (Bakker, 2014; Draaisma et al., 2021).

For MTLs, self-care goes beyond individual well-being: it involves shaping one's work in a healthy and sustainable way, nurturing professional growth, and developing a strong professional identity – understanding who you are, what you do, and how you relate to your context (Ruijters et al., 2015). This process is supported by environments that encourage learning and adaptability (Robbers & Vermeulen, 2018; Vermeulen, 2016). As professionals evolve from novice to experienced leaders, self-care takes on new forms: seeking mentorship, engaging in peer reflection, balancing ambition with realistic boundaries, and using social networks as sources of feedback and renewal (Nawijn & Van den Berg, 2020; Peltenburg et

al., 2018; Smit, 2002). Ultimately, experienced MTLs extend their self-care into relational and organizational care – mentoring colleagues, contributing to shared learning, and maintaining vitality in themselves and their teams (Nawijn & Van den Berg, 2020; Rozendaal et al., 2019).

Theorems and Bubble Diagram

As said, theorems were distilled from the transcripts and allocated to our three main themes. Examples of theorems can be found in Box 1. An exhaustive list can be found in Consortium Tools voor teamleren (2022).

Box 1. *Example of a Theorem in Each of the Three Themes*

Coaching inquiry based working in teams (IBWT): *"If the design group lacks experience with collaborative inquiry, the MTL can introduce and guide it indirectly, keeping the focus on the issue and its solution. This helps the group see the relevance of the IBWT-activities."*
Promoting alignment: *"If it is difficult to bring issues to management, the MTL can use already planned meetings or training moments to raise these topics."*
Selfcare: *"It is essential for the MTLs development to actively seek internal and external networks, gaining confidence and affirmation in their professional role."*

Next, these theorems were categorized according to their relevance for novice MTLs or reserved for experienced MTLs. While discussing this categorization our consortium noted that:

- The appropriateness of learnings related to the MTL role depends on the extent to which a school has already developed a learning culture (Ros et al, 2022). Theorems associated with experienced MTLs become particularly relevant when the school culture is also more advanced in inquiry-based ways of working.
- On the right side of the bubble scheme, MTL activities across the three themes begin to overlap. This overlap reflects the ability of MTLs to oversee the broader picture and longer developmental trajectories, enabling them to assume larger and more long-term responsibilities in working toward sustainable improvement. In this phase, MTLs are also regarded as relevant partners by other stakeholders.
- The level of MTL experience is relative to the level of contextual development. Consequently, when MTLs move to a different context, the relevance of their activities may shift along the bubble scheme, moving from left to right or vice versa.

Beginning MTLs are typically still exploring their roles and learning how to guide inquiry in schools with little tradition of such practices. Experienced MTLs, in contrast, are more strategically positioned and capable of adapting to complex challenges, acting as dialogue partners in agenda setting and strategic planning. However, the model is dynamic: experienced MTLs may find themselves in "beginner mode" when entering a new or less mature environment, and vice versa. An MTL may be highly capable in guiding inquiry but still

developing in terms of alignment or self-care. We tried to capture this in the bubble scheme as presented in Figure 3.

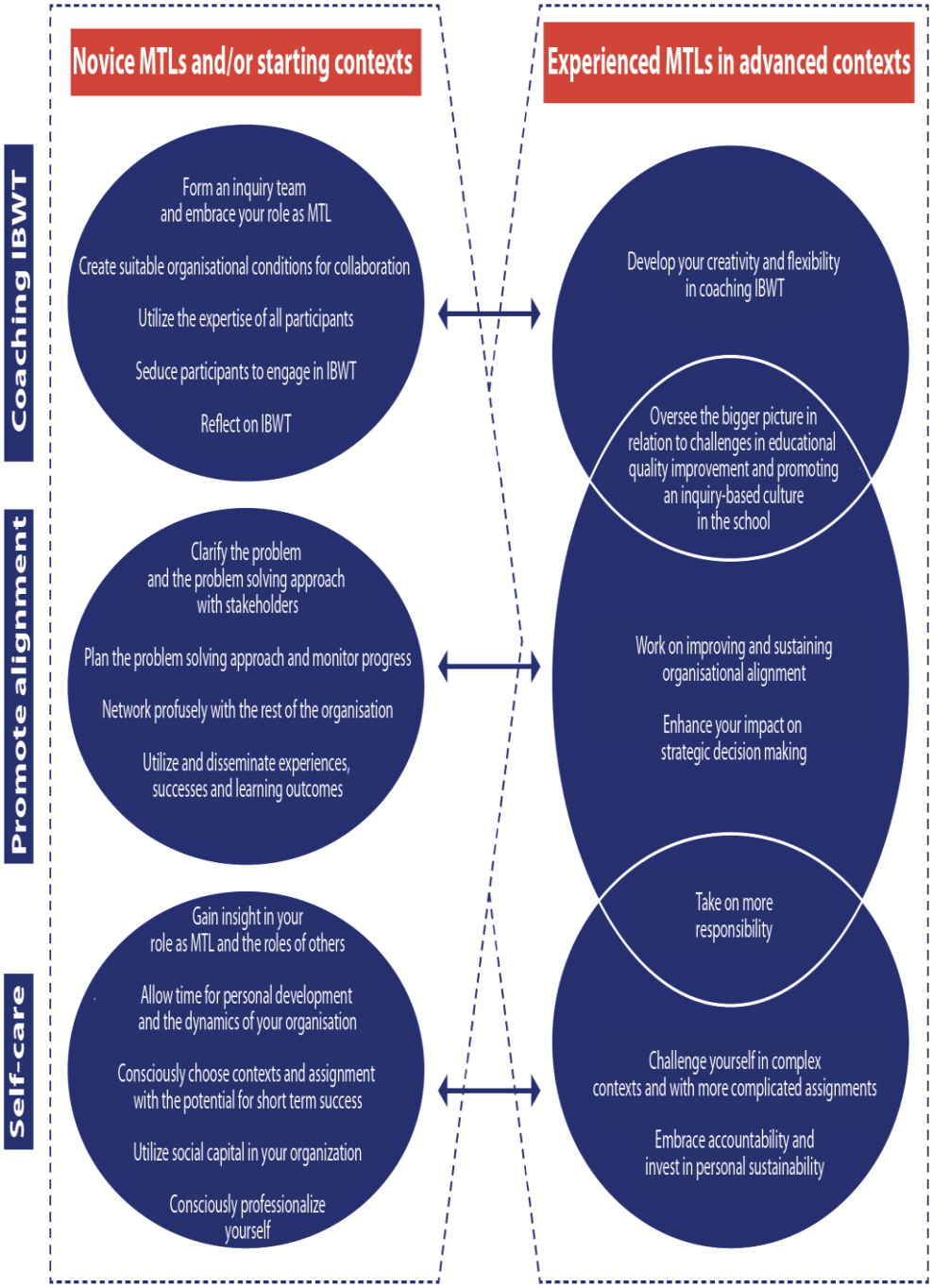

Figure 3. *Model of MTL Practices Across Developmental Stages and Contexts*

DISCUSSION

The results highlight that MTLs often operate in a demanding context. Their impact depends not only on their own competencies but also on the learning capacity and alignment of their organization. For MTLs to succeed, they must balance their role as facilitators of inquiry with efforts to build organizational alignment and care for their own professional growth. This triple focus –collaborative inquiry, alignment, and self-care – forms the backbone of the bubble scheme as developed in this research. Each theme comes with a developmental continuum, acknowledging the diverse starting points of both MTLs and school contexts.

Experience in presenting this research during conferences, workshops and in master training programs showed that MTLs can use this model to choose and reflect on their activities and adapt them to the needs of their context. As their role becomes more recognized and embedded, MTLs can grow into agile and creative professionals who guide schools through today's educational complexities. However, since paradoxally MTLs are both beneficiaries and shapers of these enabling conditions, they must continue to take initiative and actively step forward to fulfill their potential.

With respect to the actual execution of MTL activities within the bubbles that shape their role, further research is needed. This need concerns not so much the identification of types of activities, but rather the development of *actionable knowledge* (Markauskaite & Goodyear, 2017) on how to enact these activities effectively. An example of research that generates such knowledge can be found in Consortium Mozaic (2025), in which inquiry teams led by a teacher leader developed approaches to promote self-regulated learning among primary and secondary school students.

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